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PROBLEM

OF

INTEROCEANIC COMMUNICATION

BY WAY OF THE

AMERICAN ISTHMUS

BY

LIEUT. JOHN T. SULLIVAN, U. S. N.

BUREAU OF NAVIGATION

NAVY DEPARTMENT

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THE "SECRET OF THE STRAIT."

"The first bold crossing of 'the sea of darkness' links the commercial activities of the Old World with the New in the person of the great discoverer. The expectation of being able to sail westward to the Spice Islands without interruption was the principal motive of Columbus in undertaking the voyage which first marked the limits of the Atlantic. He was, as is well known, happily prompted by a geographical error of gigantic magnitude, in adopting the idea of Ptolemy's geography, which left about one-third of the globe between the supposed limits of China and Europe.

"A remarkable confirmation of this is given by Irving when he tells us that on one of those splendid voyages the opinion of Columbus that he was coasting the continent of Asia and approaching the confines of ancient civilization of the East was shared by all his fellow-voyagers, among whom were several experienced navigators; and that after fully exploring the coast toward the southwest, every one declared that there could no longer be any doubt on the subject, for it was impossible that so vast a continuity of land could belong to a mere island.

"The chief object of his last voyage indicates, in a marked degree, his idea of Asia, since it was undertaken with the single purpose of seeking along the coast of the Caribbean sea the *strait* which he imagined formed a communication between his discoveries and India. When off the coast of Veragua, he received some accounts from the Indians of a great and civilized people living in the country Ciguare; and he understood from them that ten days from that country by sea would bring him to the Ganges. He supposed that Ciguare must be some province of the Grand Khan; and as the sea was said to reach this country, it would be found on the opposite side of a peninsula bearing the same relation to Veragua that Pisa does to Venice in Italy. By proceeding further eastward, therefore, he must soon arrive at a strait like Gibraltar, through which he could pass into another sea and visit this Asiatic Ciguare, arriving at the banks of the Ganges. He therefore examined the coast of Central America from the Bay of Honduras to the Spanish Main; and although on the borders of countries far richer than those he sought, of which several striking indications were presented to him, all was lost sight of in the vain pursuit of the desired strait. Irving adds, 'He had been in pursuit of a chimera of a splendid imagination and a penetrating judgment. If he was disappointed in his expectations of finding a strait through the Isthmus of Darien, it was because nature herself was disappointed. For she appears to have attempted to make one, but to have attempted in vain.'

"This search for the secret of the strait marks the first era in the history of direct efforts for interoceanic communication across America. From this date it is a record of continuous and unavailing efforts to find the strait, and on a failure of this, a record of numberless canal and railroad projects for an artificial transit."

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SETTLEMENT OF DARIEN AND DISCOVERY OF THE PACIFIC.

Although Columbus attempted to establish a colony on the coast of Veragua in the early part of 1503, no settlement was made on the American continent until about seven years later, when Encisco effected one on the shore of Darien, near the mouth of the Atrato. It was called Santa Maria de la Antigua.

After the sailing of the expedition which was to establish this colony, a man was found stowed away in a barrel on board of Encisco's ship. "His name was Vasco Nunez de Balboa, an adventurer, a skillful master of the art of fencing, who, as he was in debt, and as indebted people could not leave the Island of Hispaniola without the permission of the authorities, had secretly contrived to get into this barrel, and to form a part of Encisco's stores."*

Such was the strange manner in which the courageous and enterprising explorer commenced his ascent to the pinnacle of fame. Possessing the necessary qualities of a great commader, his influence in the colony was soon appreciated, and in 1512 he was elected governor. Anxious to secure a

* Conquerors of the New World and their Bondsmen.

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confirmation by the Crown, he determined to gain favor by a brilliant exploit. An opportunity was soon furnished, as a result of a visit to an Indian tribe with whom friendly relations had been established. The Spaniards were not only delighted with the welcome they received in the substantial form of presents, including gold and slaves, but were surprised to find the tribe surrounded by comforts and evidences of civilization to which other tribes they had thus far encountered were strangers. While dividing the gold which they had received, after allotting a fifth part for the Crown, there arose a dispute among the Spaniards about its division. A young cacique of the tribe, observing this quarrel, became indignant and overturned the scales, saying, "What is this, Christians? Is it for such a little thing that you quarrel? If you have such a love for gold that to get it you disquiet and harass the peaceful nations of these lands, and suffering such labors banish youselves from your own lands, I will show you a country where you may fulfill your desires, but it is necessary for this that you should be more in number than you are now, for you would have to fight your way with great kings, and amongst them, in the first place, with King Tubanama, who abounds with this gold, and whose country is distant from our country six suns." He then indicated that a journey to the south would bring them to another ocean, and, traversing that to the southward, they would be brought to the shores of the kingdoms abounding in gold.

Elated with this news, which developed the prospect of his being able to achieve success where Columbus had failed, he immediately set about organizing a sufficient force and making necessary treaties with the neighboring caciques for aid. His preparations finished, he set out by sea from Santa Maria de la Antigua on the 1st of September, 1513, and landed his band of hardy adventurers in the vicinity of Caledonia Bay. His force consisted of 190 Spaniards, 1,000 Indians, and a number of fierce dogs, which latter were deemed highly serviceable on account of the fear the Indians had of them.

To enter an unexplored country, dependent upon guides whose very object might be treachery, and the certainty of exposure to many dangers which could not be provided against, entitles this enterprise to consideration as one of the boldest ever undertaken by man.

Entering the wilderness with his band, Balboa commenced the march, which, amidst great suffering, was prolonged for twenty-five days instead of six, as had been indicated. Beset on one hand by the hostility of the natives through whose territory they were advancing, and on the other by the rugged character of the country, with its pestilential climate, and an absence of food, it was no wonder that his followers became discouraged. Nothing short of the indomitable will of their leader, and the possession of their confidence and affection, could have enabled him to control them in their state of discouragement. Finally, as their endurance was tested to nearly the utmost limit, the Indians promised a view of the sea from a neighboring hill.

Arriving near the summit, Balboa advanced alone to meet the view of the great South Sea, and, animated with a feeling of gratitude that it had been reserved for him to confer upon his country the benefit of so great a discovery, fell upon his knees and fervently returned thanks to Heaven. His followers were soon at his side to participate in the grand emotions caused by the magnificent spectacle, and to share in the joy resulting from a happy consummation of their wishes.

Continuing on their journey, they soon reached the sea, in the vicinity of the Gulf of San Miguel, where Balboa entered its waters and took possession in the name of his King.

Balboa now received definite information regarding Peru, and soon commenced preparations for the purpose of attempting its conquest, but was continually thwarted and humiliated by Pedarius Davila (Pedro Arius de Avila), described as "a suspicious, fiery, arbitrary old man," who came out from Spain as the newly appointed governor of Darien. Balboa's rewards consisted of empty titles. His influence with the troops and natives was unlimited, and could have been directed against his persecutor had he so desired, but he quieted his partisans and submitted without a murmur. Before he was ready to sail on his voyage of conquest, Davila's jealousy was aroused against him, and on false charges, before a court of his own creatures, he had Balboa condemned and brought his head to the block.

The pictures of the glory of these early achievements present a strong contrast when viewed with those showing the pain and misery which accompanied them. Las Casas remarks that "the sufferings of the Spaniards in the New World, in search of wealth, have been more cruel and severe than ever nation in the world endured." In the case of the followers of Pedarius Davila, it is

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said that the provisions had suffered deterioration on the voyage, and, as a result, "men in silk and brocades absolutely perished of hunger, and might be seen feeding like cattle upon herbage. One of the principal hidalgos went through the streets saying that he was perishing of hunger, and in sight of the whole town dropped down dead. In less than a month seven hundred men perished."* Irving states that "the perils that lay in the discoverer's path, and the sufferings he had to sustain, were scarcely inferior to those which beset the knight-errant. Hunger, and thirst, and fatigue, the deadly effluvia of the morass, with its swarms of venomous insects, the cold of the mountain snows, and the scorching sun of the tropics, these were the lot of every cavalier who came to seek his fortunes in the New World. It was the reality of romance. The life of the Spanish adventurer was one chapter more, and not the least remarkable, in the chronicles of knight-errantry."†

Pedarius Davila ultimately regarded the locality of the settlement of Santa Maria as unsuitable for the prosecution of contemplated voyages in the Pacific, and, moreover, on account of its unhealthfulness, sought and obtained permission to remove the colony. This was done in 1519, the new locality chosen being an Indian village, near the site of the present city of Panama. It was here that Francisco Pizarro, availing himself of the knowledge he acquired about Peru while a companion of Balboa, fitted out the expedition for the conquest of that kingdom. The rich commerce resulting from this successful exploit sought an expeditious transfer from ocean to ocean, and to meet this want a road was soon opened and paved from Panama to Porto Bello. At a stated time every year the richly laden ships from Spain would rendezvous at Carthagena, on account of its better climate, and await news of the arrival at Panama of the galleons from Peru, when, proceeding to Porto Bello, a fair would be held for sixty days, during which all the exchanges would be made under the supervision of the governor of Panama and the general of the galleons. The fair was attended by all the merchants of the Spanish Main, and it is said that none in the world was equal to it.

"Granada, named after one of the richest provinces of Spain, was the modern Ophir, while Porto Bello represented the Tarshish of the most brilliant period of the Hebrew monarchy. As in Tyre and Sidon, 'its merchants were princes,' but like all other ancient emporiums to which commerce was compelled, or which obtained an adventitious and illusive importance, Porto Bello has fallen, and the route between it and Panama Harbor wholly abandoned. The extreme unhealthfulness of the city, which gave to it the appellation of the 'grave of the Spaniards,' led to its abandonment, and the mart of Spanish America and the receptacle of the wealth of the Indies is now scarcely visible from the anchorage, owing to the dense jungle which has grown up in tropical luxuriance over the ruins of the city."‡

RENEWED EFFORTS IN THE SEARCH FOR THE STRAIT.§

"The discovery of the Pacific by Balboa, and its entrance by Magellan, kept alive for more than a quarter of a century the erroneous ideas of the strait. Since it was now certain that the new lands were not the Indies, the next thing was to carry forward the search for the narrow passage which must lead to them. The very configuration of the Isthmus strengthened the belief in the existence of such a passage by the number of its openings, which seem to invite entrance in the expectancy that some of them must extend across the narrow breadth of land. For this great purpose, and in full expectancy of success, the whole coast of the New World on each side, from Newfoundland, as visited by the Cabots, on the northeast, and thence south around the whole sweep of the Mexican Gulf, and the Caribbean Sea, around South America, and up the Pacific to Behring Straits, was searched and researched with diligence. Men, says Humboldt, could not accustom themselves to the idea that the continent extended uninterruptedly from such high southern to such high northern latitudes.

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* "The Conquerors of the New World, and their Bondsmen."

† Irving's "Life of Columbus."

‡ Paper on Interoceanic Communication, by Lieut. I. C. Strain, U. S. N.

§ From MSS. of Prof. J. E. Nourse, U. S. N.

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"The year after the discovery of the South Sea, the King of Spain had given secret orders to D'Avila, governor of Castila del Oro, and to Juan de Solis, the navigator, to determine whether Castila del Oro, a part of Columbia, was an island; if a strait could possibly be found; and to send a chart of the Isthmus to Cuba. De Solis passed along the whole coast of Brazil, but, entering La Plata, was there massacred by the natives.

"In 1516 Ponce de Leon sailed 140 leagues along the west coast from Panama, discovering the port now called Nicoya. In 1517 the Spaniards founded Nata, on the west side of the Bay of Panama, their first settlement on the shores of the South Sea, and in a year or so later they established themselves at Panama. The design of prosecuting discoveries thence towards the Spice Islands then assumed a regular form. Ships were fitted out, and a commander-in-chief appointed by the court of Spain to oversee their construction and equipment; but the undertaking failed in consequence of the wood of which they were built becoming worm-eaten within a month after their launching into salt water.

"The continuous search for the strait, made under the orders and direct superintendence of Cortez, at length resulted in putting an end to all hope in that direction. Charles V had urged the search. In a letter from Valladolid, in 1533, he enjoined the most careful inquiry 'for the passage which would connect the eastern and western shores of the New World, and shorten by two-thirds the route from Cadiz to Cathay;' and Cortez, in his reply, expressed the highest hopes of success. 'It would render the King of Spain master of so many kingdoms that he might call himself Lord of the World.' The instructions of the court and the subsequent letters of the conqueror, as well as the correspondence of men of science, were always full of the idea. 'For the proximity of the two oceans in certain parts of the Isthmus having been by this time ascertained, it could not yet be believed that nature had worked on a plan so apparently repugnant to the interests of humanity as to interpose, through the whole length of the new continent, such a barrier to communication between the great seas.' The conqueror of Mexico never abandoned this leading object in his reverses, nor forgot it in his triumphs. His fleet fitted out for exploration on the Pacific side being burned in the dock-yard of Zacatula, he quickly got ready a second, a third for exploration in the direction of Florida, and a fourth for the coast of Honduras.

"Again, in 1530 and in 1532, two other squadrons were sent on a voyage of discovery to the northwest, and, on their failure, Cortez made his own search from the port of Santa Cruz in a fleet fitted out at Tehuantepec. He crossed the Gulf, but was driven to the last extremity of famine; again crossed it, was tossed about by terrible tempests, without a pilot to guide him, and was thrown upon the rocks, when his vessel nearly went to pieces. Yet he brought back his crazy ship into port. These expeditions were well planned, and he was liberal in his experiments, although they ended disastrously in a pecuniary point of view. But on a subsequent voyage he discovered California, and his fleets, conducted in part by himself, determined its whole extent and its junction with the continent. The Gulf for a long time was known by the name of Mar de Cortez. The Pacific was coasted from the Bay of Panama to the river Colorado. The vast tract which had been supposed to be an archipelago was discovered to be a part of the continent, and its general outline, as appears from the maps of the time, became nearly as well understood as at the present day. He ascertained that, instead of the outlet before supposed to exist towards the north, the unknown ocean was locked up in the arms of the mighty continent. The hope of finding a short passage across the Isthmus thus perished.

"Voyages for discovery, for commerce, for possession of the soil, and in search still of a western route continued to be made by the English, French, and Portuguese throughout the century. Through ignorance of the breadth of North America, a faint hope of reaching the South Sea by a short route seems to have lingered long in the minds of the English, for Bancroft tells us 'that it was expressly enjoined on the Virginia colonists of 1607 to seek a communication with that sea by ascending some stream which flowed from the northwest,' and that the captivity of Capt. John Smith was the result of Smith's obedience to his instructions by his following up the Chickahominy. But Cortez and his followers had long before consigned to mythic realms 'the secret of the strait.'"

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Map of the Isthmus showing the localities which have been made the subject of study or exploration, and also the position of the "divide" with reference to the Atlantic and Pacific coasts.

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CHAPTER II.*

EARLIEST PROPOSALS FOR A CANAL—ACTION OF PHILIP II AND ITS RESULT—HISTORICAL ASSOCIATIONS OF THE CALEDONIA ROUTE, THE PARENT OF THE ISTHMIAN ROUTES, AT THE CLOSE OF THE SEVENTEENTH CENTURY—PATERSON'S GRAND PROJECT—EFFORTS TO EXECUTE IT BY COLONIZATION—THE SCOTCH COLONY OF DARIEN—MILLA'S RECONNAISSANCE.

EARLIEST PROPOSALS FOR A CANAL.

"The barrier to a direct route to India being recognized, it was natural that attention should be turned to the problem, which now offered itself, of securing an artificial communication, and that its solution was to be found in that long and narrow isthmus which was now shown to connect the two continents of America.

"The Spanish historian, Gomara, seems first to have proposed an artificial opening through the Isthmus. In 1551, representing, doubtless, the general feeling in Spain and in the New World, he urged on Philip II the union of the oceans by three of the same routes which at this day are still before the world, Tehuantepec, Nicaragua, and Panama; and had Spain remained what she had been under Charles V, what had been in vain sought from nature might have been in some degree supplied by man. Her men of science had urged the work, and all Spain had awakened to it.

"'How majestic and fair,' says Chevalier, in his L'Isthme de Panama, 'was Spain in the sixteenth century. Never had the world seen such energy, activity, or good fortune. Hers was a will that regarded no obstacles. Neither rivers, deserts, nor mountains, far higher than those in Europe, arrested her people. They built grand cities; they drew their fleets, as in a twinkling of an eye, from the very forests. A handful of men conquered empires. They seemed a race of giants or demi-gods. One would have supposed that all the work necessary to bind together climates and oceans would have been done at the word of the Spaniards, as by enchantment, and since nature had not left a passage through the center of America, so much the better for the glory of the human race; they would make up the loss by artificial openings.'

"'It is true,' said Gomara to the Emperor, 'that mountains obstruct these passes, but if there are mountains, there are also hands. Let but the resolve be made, there will be no want of means; the Indies, to which the passage will be made, will supply them. To a King of Spain, with the wealth of the Indies at his command, when the object to be attained is the spice trade, what is possible is easy.'

"But the sacred fire had burned itself out. The Peninsula had a ruler who sought his glory in smothering free thought among his own people, and in wasting his immense resources in vain efforts to repress it also outside of his own dominions through all Europe. From that hour Spain became benumbed and estranged from all the advances of science and art, by means of which other nations, and especially England, developed their true greatness.

"Even after France had shown by her canal of the South that boats could ascend and pass the mountain crests, it does not appear that the Spanish Government seriously wished to avail itself of a like means of establishing any communication between the Antilles and the South Sea. The mystery enveloping the deliberations of the Council of the Indies has not always remained so profound that we could not know what was going on in that body. The Spanish Government afterwards opened up to Humboldt free access to its archives, and in these he found several memoirs on the possibility of a union between the two oceans; but he says that in no one of them did he find the main point, the height of the elevation on the Isthmus, sufficiently cleared up, and he could not fail to remark that the memoirs were exclusively French and English. Spain herself gave it no thought. Since the glorious age of Balboa, among the people, indeed, the project of a canal was in every one's thoughts. In the very wayside talks, in the inns of Spain, when a traveler from the New World chanced to pass, after making him tell of the wonders of Lima and Mexico, of the death of the Inca Atahualpa, and the bloody defeat of the Aztecs, and after asking

* The first part of this chapter to the line of asterisks is quoted from MSS. of Prof. J. E. Nourse, U. S. N.

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his opinion of El Dorado, the question was always about the two oceans, and what great thing would happen if they could succeed in joining them.

"The Spanish Government alone cared nothing for it. For years there was not one publication upon the subject which the humblest of our civil engineers would not now deem beneath his study. It became a mere idea and legend. The long wars of the Spanish monarchy and its fearful decline almost consigned the very idea to oblivion."

"The most serious complaint in this historic statement lies against the unwillingness of Spain to improve even her interoceanic land-routes. She had need of the best mode of conveyance for her treasures across the Isthmus, yet those from Peru came by the miserable route from Panama to Porto Bello, while her European wares for her colonists toiled up the Chagres River, and farther north only the roughest communication continued to connect the Coatzacoalcos and the Chimalapa, trade being restricted to one port only on each side. To the selfish policy of Philip II is to be attributed this unwillingness to improve the existing routes or to search for better. Viewing with a jealous eye the wealth of the newly acquired kingdoms, he feared that a more accessible route to them would enable other nations to dispute with Spain for their possession, and to provide effectually against such a contingency it was prohibited, under pain of death, to seek or make known any better route for the existing traffic; and as the Atrato was supposed to lead to a point from which there were superior facilities for communicating with the Pacific, it was decreed that death would be inflicted upon any person whatever attempting its navigation. Influenced by this same policy, Spain guarded carefully all the acquisitions to her geographical knowledge, particularly of such as Darien possessing gold mines, resulting from researches made in this direction during the end of the last and beginning of the present century.

"Of the work of these periods prominent writers agree that the surveys were accurate, and Admiral Fitzroy, R. N., states that 'no surveys need be better.' The interior of Darien could not be developed, owing to the hostility of the Indians, but very good maps of much of the Spanish territory existed at the time she gave up her American possessions, but in the repeated copyings so many errors have crept in that work originally good has been rendered almost worthless.

"This exclusive policy of Spain was manifested as late as 1775, when, on the presentation of a memoir by the citizens of Oaxaca for improving the Tehuantepec route, the memorialists were censured as intermeddlers, and the viceroy fell under his sovereign's displeasure. Later in the century the attention of the Spanish Government was once more called by Goday, the Prince of Peace, to the alleged practicability of a canal, and a reconnaissance of a route was made under his direction, the documents in regard to which, Mr. Squier tells us, still exist in the archives of Guatemala. Nothing practical was done, however, nor were further plans or projects submitted during the remainder of the iron rule of Spain over her colonies, except a partial examination of a route across Tehuantepec, made under the orders of the viceroy by Cramer and Corral. At the date of 1814 the Spanish Cortes did, indeed, decree the construction of a canal, but the execution of this decree was not even attempted.

"Yet it is perhaps scarcely necessary to remark on the character of any canal which might have been constructed within the times referred to, that such a work as would have been built could have secured little beyond a local and inland traffic, and that it would have been utterly out of proportion to the demands of commerce of later days."*

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A source of real regret, however, is found in the policy of Spain which stifled geographical research on the Isthmus. The early successes of the Spaniards had stimulated them to the highest degree of adventure; through a ceaseless activity and enterprise the New World was rapidly giving up its secrets, and, had this activity continued, the problem of interoceanic communication would not have been handed down to the present century with so many unknown quantities.

HISTORICAL ASSOCIATIONS OF THE CALEDONIA ROUTE, THE PARENT OF ISTHMIAN ROUTES, AT THE CLOSE OF THE SEVENTEENTH CENTURY.

Notwithstanding the efforts which Spain made to reserve to herself all knowledge of favorite routes for interoceanic transit, it was impossible for her to prevent the buccaneers from acquiring

* From MSS. of Professor Nourse.

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some of it, aided as they were by the Darien Indians. These latter, appreciating the effective manner in which these adventurers harassed the Spaniards, advised them of localities rich in booty, and accompanied them in expeditions against their common enemy. The route lying between Caledonia Bay, on the Atlantic, and the Gulf of San Miguel, on the Pacific, the one followed by Balboa in 1513, was used in 1680 by a party of English buccaneers in an expedition directed against the settlement of Villa Maria, on the Tuyra River, the depot for all the gold collected in the neighboring mountains. The party, consisting of 300 men, under Captain Sharp, accompanied by a large force of Indians, set out from Caledonia Bay on the 5th of April, 1680, and on the ninth day of their journey they came near Villa Maria, which they stormed and sacked the following morning. They were disappointed in their hopes of a rich booty, as most of the gold, three hundred pounds, had been shipped for Panama three days before, and only twenty pounds remained. Here, as a result of dissensions common to such organizations, the party divided, one portion proceeding in canoes to Panama, where they captured some Spanish vessels, the other returning to the Atlantic coast by a somewhat different route than that followed in crossing.

A few years after this adventure of the buccaneers, the Caledonia route was brought into prominence through the exertions of William Paterson, who conceived the grand idea of establishing at this portion of the American Isthmus a distributing center for the commerce of the world.

"It was Patterson's original and ostensible design," says Malcolm Laing, a Scottish historian, "to establish an East Indian trade with Scotland, to which foreign merchants, impatient of the exclusive companies in England and Holland, might subscribe. But a secret and magnificent plan was engrafted by Paterson upon his original designs."

The modification of his scheme resulted from experience gained as a merchant in the West Indies, and from information respecting the Isthmus received from the buccaneers. A new line of development was thus opened for his grand idea, and after study and reflection he matured the plan of colonizing Darien, to unite the commerce of the two Indies, and, in his own language, to give to Great Britain "the keys of the world", that she might "order matters so as may best shake and overturn the present tyranny in the Indies, that the nations everywhere may get an opportunity and be induced to set up for themselves, and be for the future enabled to maintain the freedom of their governments and trade, under the glorious and easy protection of His Majesty," as the command of "these doors of the sea and the keys of the universe would, of course, be capable of enabling their possessors to give laws to both oceans, and to become arbitrators of the commercial world, without being liable to the fatigues, expenses, and dangers, or of contracting such guilt and blood as Alexander and Cæsar."

His conception of the good to come was not limited to that which would redound to Great Britain alone, but extended to all nations, and he appealed to her to control the commerce of the world in the interests of free trade.

Referring to incidents in Paterson's life, Bannister* says his biography "might be extended with advantage over the important period from the reign of Charles II to that of George I. He was a great authority upon trade and upon finance, an eminent political economist, a practical statesman, and a sagacious colonial projector; a powerful writer, a true patriot, and a thoroughly honest man. * * *. His active mind embraced all the great questions of an unusually eventful age. * * * All that he accomplished he owed to the resources of his own clear intelligence, and to his character, without the help of high birth or fortune. His extraordinary influence over men's minds sprang from his personal superiority. A stranger in London, and a Scot, he combined the rich English elements of the bank, of which he was one of the first directors.† A wanderer from home, he roused all Scotland to take part enthusiastically in a trading and colonizing scheme, then quite new to the experience and habits of his cautious countrymen; he was one of the leaders of the enterprise in its destination beyond sea, when it was destroyed through the jealousy of rivals and the hostility of Spain; and he came home a ruined man, but preserved the affectionate respect of all."

While it is unnecessary to enter into a history of this scheme, it will be of interest to do so,

* Central America, by William Paterson, the merchant-statesman. From a MS. in the British Museum, 1701. Edited by S. Bannister, M. A., Queen's College, Oxford.

† He was the founder of the Bank of England.

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and, moreover, it has some claim to attention, as its object was so closely allied to that of the contemplated interoceanic canal. This history, however, while comprehensive, should have the merit of brevity, and as it is hardly possible to satisfy these requirements more fully than Lieutenant Strain has in his paper already referred to, his compilation will be quoted. An additional object will be to recognize the merits of this brave officer in a field in which he is but little known.

THE SCOTCH COLONY IN DARIEN.

"The discoveries of the Spaniards in America, the overcolored narratives of the buccaneers, and the immense profits of the English East India Company, which, availing itself of the discoveries of Vasco da Gama, the intrepid Portuguese navigator, sent annually its immense fleets to the peninsula of Hindostan and to the neighboring islands, infected the Scotch, perhaps the least enthusiastic people of Europe, and in 1695 a company was formed in Edinburgh for the purpose of trading with Africa and the Indies.

"The company, as constituted by the Scottish Parliament, held an exclusive privilege for thirty-one years, was possessed of full administrative and judicial powers, and in consideration of its charter was bound to pay to the King of England one hogshead of tobacco annually. In the original plan one-half the stock was to be reserved for citizens of Scotland, and the subscriptions limited between one hundred and three thousand pounds. After a thorough organization, subscriptions for stock were opened in London, Amsterdam, and Hamburg, in each of which commercial cities it was rapidly taken. In Hamburg alone £200,000 were soon subscribed, and in London, nine days' subscription amounted to £300,000.

"The progress of this trading company excited the jealousy of that stupendous monopoly, the East India Company, and representations against it speedily flowed in upon the ministry. Nor was this selfish opposition confined to those interested in the preservation of the East India monopoly; the English Parliament also made representations against it to the King, and declared the principal promoters of it guilty of a misdemeanor. The Government was not behindhand in their efforts against the company, and after compelling the London merchants by threats of impeachment to withdraw their subscriptions, protested against the subscriptions of the citizens of Hamburg, and warned them through its minister not to proceed or continue to give pecuniary aid to the Scotch project. The answer of the citizens of this free town to the protest and threats of the English representative was worthy of their reputation. 'They considered it strange that the King of England should dictate to them, a free people, how or with whom they should engage in arrangements of commerce.' Notwithstanding the bold independence of their reply, believing that William would take measures to thwart the company, their subscriptions, as well as those of the Dutch, were withdrawn, and the Scotch left alone to struggle against the united hostility of England and Spain. The enthusiasm of the Scotch had been aroused, and inexcusable opposition developed that obstinacy which is an important element in their character. In about one year £400,000 were subscribed in Scotland alone, and the list of subscribers and directors, which is still extant, contained some of the most distinguished names in the kingdom. To appreciate fully the value of this pecuniary risk, it ought to be remembered that this £400,000 was one-half the circulating medium of Scotland. It was, in fact, the first attempt of Scotland to colonize, and the national pride was aroused. Volunteers flocked in from all sides, and when the expedition was ready to sail, many who had been refused for want of accommodations were found hidden in the holds of the ships. The first colony consisted of twelve hundred choice men, among whom were two hundred belonging to the best families in the kingdom, and sixty officers whom the peace had thrown out of employment. For their conveyance, three stout ships and two tenders were provided.

"On the 26th of July, 1698, enthusiasm in Scotland rose to its highest, and all Edinburgh came out to witness the sailing of the expedition. Nor was the excitement confined to Scotland, for, says Dalrymple, 'Neighboring nations saw with a mixture of surprise and respect the poorest nation in Europe sending forth the most gallant colony which had ever gone from the Old to the New World.' On the next week after the sailing of the expedition the Scotch Parliament convened, and forwarded an unanimous address to the king, asking his support and countenance; but he, actuated by a general prejudice against the nation which still retained a love and respect

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for the unfortunate Stuarts, by the selfish representations of Parliament and the East India Company, and the remonstrances of the Spanish minister, peremptorily refused, and caused orders to be expedited to the Governors of New York and Jamaica to withhold supplies from the new settlement. In this order were involved the germs of the destruction of the Darien colony.

"The colonists arrived safely at Darien, and landing about seven miles from Golden Island, on a small peninsula which formed a secure harbor, commenced the erection of habitations and fortresses for their protection. To the adjoining bay they gave the name of Caledonia; to their harbor, Scotch Port; and to their town, the ruins of which are no longer visible, New Edinburgh. With the Indians, who were found to be friendly, a perpetual treaty of peace and amity was duly signed, and deputations were received from the Spanish colonies of Carthagena and Panama, which did not feel confident to cope with so formidable a force of hardy Scotchmen. Soon after landing, the council, which was in charge of the administration of the affairs of the colony, issued a proclamation conceding to all nations the same privileges as to Scotch subjects, and declared an unlimited freedom of commerce. Religious toleration was also proclaimed, but with certain reservations which bore the impress of their Scotch Presbyterian origin.

"In April, 1699, a Parliament was assembled and laws were passed for the government of the colony, which, as transmitted to us, bear the impress of the liberal and benevolent spirit of the gentle Paterson. The protection of the Indians against the young and reckless, who saw no harm in 'spoiling the heathen', was amply provided for by these laws. No person could be confined for more than three months without a trial, and in all criminal cases the accused, as in Scotland, was entitled to a jury of fifteen of his countrymen. No imprisonment for debt was permitted, unless upon proof that fraud was intended. At the instance of Paterson, servitude was abolished, and each one became a freeholder by the division of land, thus making the colonists independent, and depriving the colony of the advantages of combination in labor. This was the first great error, as afterwards that concentration and singleness of purpose which is essential in a new country could not be attained.

"A member of the council, writing home, says it would have been 'better to have three years' servitude, and a division of land afterwards;' and in speaking of the colonists, says: 'They had no true notion of liberty. The thought of it made them insolent, and ruined command.' Even under the disadvantages which this premature concession entailed upon the colony, it yet might have flourished if they had been controlled by a competent leader. Paterson, as the projector, a director, and prominent member of the council, enjoyed the greatest consideration and influence; but although great in conception, his gentleness and modesty made him an inappropriate ruler of the turbulent elements by which he was surrounded. Of his honesty and integrity of purpose he had given many evidences. Among others was the voluntary resignation of 2 per cent. on stock and 3 on profits, which, in consideration of his services, had been conceded by the company and assured by the Scotch Parliament. These sacrifices and his mild deportment contributed to his personal popularity, but not to his authority; nor did it inspire his subordinates with that respect and confidence without which no leader of men, and especially of discordant elements held loosely together by recent laws of their own making, can ever be successful.

"The time occupied by the colonists in erecting houses and fortifications prevented them from tilling the land, and their principal dependence for the means of sustaining life was upon supplies from abroad. Much of the provisions which they brought from Scotland proved to be bad, and the use of them produced sickness, which rapidly diminished their numbers.

"The cruel proclamation of the King of England now began to produce its bitter fruits. From English colonies they could obtain no supplies. Scotland was distant, and its people unaware of the sufferings of their friends; while the Spaniards of Panama, Porto Bello, and Carthagena looked with satisfaction on the sufferings of a colony which had threatened to prove formidable to their interests. In this extreme emergency, the Indians, more generous than the English, who owed it protection, contributed aid from their scanty stores. Insubordination, in which some of the members of the council were implicated, made its appearance, and a plan was laid by the mutineers to seize a single ship and make their escape from the threatened famine. The exploits of the buccaneers, which were then so recent as to infect by their example, pointed out a means of escaping from approaching death and of grasping that wealth which the colony had failed to

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produce. The younger men, incited by the young nobles, proposed to seize some of the most effective ships and retrieve their fallen fortunes by descents upon Porto Bello and Carthagena.

"For a while this mutinous spirit was quelled, and a vessel was dispatched with an humble petition to William for his countenance and protection, and an urgent request to the directors for provisions. Meanwhile the board of directors had not been idle or neglectful, and, in view of the proclamation of the King of England, had dispatched a brig laden with stores, which unfortunately never reached its destination. A reinforcement of three hundred men was also sent but before they could arrive the fate of the first Scotch colony was decided. Paterson, ill with the fever and broken in spirit, could not resist the general determination to abandon the Isthmus, and on the 22d of June, 1699, or less than eight months after their arrival, the remaining colonists embarked for the English West India Islands and North America. In September of the same year the unfortunate projector of this ill-fated expedition was in Boston, and his mental condition may be inferred from a passage in a letter written by a friend: 'Grief has broken Mr. Paterson's heart and turned his brain, and now he is a child; they may do what they like with him.' He subsequently recovered and returned to England, but appears to have taken no further part in the affairs of the company.

"The Scotch, with their characteristic pertinacity of purpose, and regardless of previous misfortunes, dispatched a reinforcement of one thousand three hundred men in four ships; but upon their arrival they found that the vessels that had preceded them, after touching at Caledonia Bay, had sailed for Jamaica. The condition of the town of New Edinburgh was most discouraging. The huts had been burned, the forts dismantled, the tools and agricultural implements taken away, while its site was overgrown with a dense jungle, which sprang up like the gourd of Jonah, in a moist, tropical climate. Many of the councillors became dejected at the condition of things, and there was a general cry to be taken home. In view of their misfortunes the Spanish displayed hostility, and Drummond, availing himself of a temporary enthusiasm, produced by an advantage which had been gained by a detachment of the colonists, proposed that they should anticipate attack and supply their wants by a descent upon Porto Bello.

"Drummond, who was an old officer of the army, assumed for a time the position to which his ability and energy entitled him; but the colonists were discouraged, timid councils prevailed, and he was placed under arrest. About this time Colonel Campbell, of Finab, arrived from Scotland with three hundred of his own men, and, releasing Drummond, temporarily restored order, and gained a victory over one thousand six hundred troops who had advanced upon them from the Spanish colonies, he himself receiving a serious wound in the action. This advantage, however, was gained too late to restore the fallen fortunes of the colony, as the harbor was now blocked up by a Spanish fleet of eleven vessels, which had arrived under the command of the Governor of Carthagena, and the fort invested by troops which had been landed and had effected a junction with those who had arrived by land.

"The garrison, discouraged and mutinous, loudly urged their leader to capitulate. This was finally agreed to by Veitch, Campbell being ill with the endemic fever. With all their stores they weighed anchor on the 11th of April, 1700, and took their final leave of the fatal shores of Darien, after an occupation of four months. During the voyage to Jamaica, Veitch died, and soon after the vessel, which he owned and commanded, was wrecked on the coast of Cuba. A vessel of the company was lost near Carthagena and the crew made prisoners. Another was lost, with a large number of her crew, while leaving Caledonia Bay; and it is said that of three thousand men who sailed for that unfortunate colony not more than twenty returned to their native land. The projector of the grand enterprise, after one more effort to retrieve his fallen fortunes, died in obscurity, pitied, but respected. It has been said in his praise by a cotemporary, that 'He was void of passion, and that he was one of the few of his countrymen who never drank wine.' Such were the unfortunate results of the only attempt ever made by Scotland at colonization, and of one of the earliest and most comprehensive schemes for opening an interoceanic communication. On account of the fact that its history is little known, I have, perhaps, here devoted to its consideration more time and space than its importance merited. It is, moreover, a subject of interest, as the same subject has been so recently revived and met similarly disastrous results."

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After the departure of the Scots the Spaniards established the military post of Agla in Caledonia Bay, and until 1790 were active in creating similar establishments and missions on the rivers which enter the Gulf of San Miguel, with the hope of securing supremacy over the Indians. At this time, recognizing their inability to gain this without an expenditure incommensurate with the object, a treaty of peace was concluded, by which they agreed to abandon all their garrisons in the Indian country.

A few years before the making of this treaty an attempt was made by the Spaniards to bring their Atlantic and Pacific posts into communication by means of a military road. With this view, a fort called Puerto Principi was built and garrisoned on the Savana River, and a trail cut thence to the Chucunaqua, striking it somewhere in the vicinity of the mouth of the La Paz. This was called Ariza's road, after the governor of the province of Darien. In an interval of peace existing with several tribes, their consent to the continuation of the road was obtained, and the services of the Sucubtis secured to aid in opening it. In 1788 Manuel Milla, adjutant of the post of Agla, accompanied by Suspani, a Sucubti chief, left Caledonia Bay to pass over the Cordillera and report upon the practicability of constructing this road. He arrived safely at Puerto Principi, but being alarmed at a rumor that his movements were watched by some of the Indians who still remained hostile, he returned to his post by way of Panama and Porto Bello. This undertaking claims attention only on account of its being one of the first which had for its direct object interoceanic communication, and not from any valuable results arising from the young officer's observations, although his performance was regarded highly by his superiors. In his report he says that in crossing the "Montana Grande" there is not a difficult pass, "with the exception of a ravine at the commencement, which four men could level off with spades in less than an hour." It must have been an extraordinary ravine. In another place he mentions the chief obstruction in the road to be a large tree which has fallen across the trail, and very ingeniously suggests that the difficulty of cutting it in two may be avoided by walking around it.

Two years after Milla's reconnaissance (1790) the Spaniards abandoned the Indian territory, and no attempt was made to study this route until more than sixty years later.

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CHAPTER III.

INTEREST IN THE SUBJECT OF INTEROCEANIC COMMUNICATION AWAKENED BY HUMBOLDT—DISTINCTLY MARKED ERAS IN THE DEVELOPMENT OF THE PROBLEM—EFFORTS OF THE SPANISH-AMERICAN REPUBLIC TO SECURE ITS SOLUTION—EARLY INTEREST TAKEN BY THE UNITED STATES AND OTHER COUNTRIES.

EFFORTS FOR A CANAL MADE BY THE CENTRAL AMERICAN STATES.

The long repose which settled upon the subject of interoceanic communication was well broken by the energetic labors of the illustrious Humboldt, who, in 1808, attracted the attention of the world to this important problem, and indicated the localities which he deemed worthy of study. Feeling the want of sufficient and authentic data for a comparison of even the best known routes, and the almost complete absence of data respecting those of Darien, he urged the necessity of proper investigation, and stated his belief that in either Darien or the valley of the Atrato would be found the solution of the problem.

Gaining their independence, the Spanish-American states were thrown open to citizens of all nations, and during the first years of their existence praiseworthy attempts were made in the line of exploration and geographical research; but the unstable character of the states prevented an undisturbed study of their territory, and particularly of Darien, as their weakness rendered them powerless against the Darien Indians who had successfully resisted the conquering arm of mighty Spain.*

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"In 1823 the new 'Republic of the Center of America' evinced an interest in the construction of a canal almost immediately on acquirement of independence from Spain. Señor Manuel Antonio de la Cerda, afterwards Governor of the State of Nicaragua, urged the matter upon the Federal Congress, but without effect. The states, exhausted by their effort to overthrow their former government, and still more by their intestine commotions, could not be expected to undertake, without the assistance of foreign capital, a work of such vast magnitude. They have nevertheless demonstrated their sense of its importance to their own prosperity, as well as to that of the commercial world; and, what redounds still more to their honor, have expressed their readiness to receive the aid of other nations towards this enterprise, upon conditions which manifest a disposition to waive, for the welfare of mankind, every narrow and unsocial suggestion of local interest.

"The chief movements towards the work from that date refer themselves to a few marked eras, specially to the years 1824–'26, 1828–'30, 1835–'38, 1846–'47, and to the much more important progress made since the year 1849. The last-mentioned date being that of the acquisition of California, and the discovery of its vast mineral wealth, is the era from which public attention in America and Europe began to give the problem practical form.

"The earliest of these movements connect themselves with Nicaragua and Tehuantepec. February 8, 1825, Señor Antonio José Cañaz, minister of the 'Republic of the Center,' addressed a note to Mr. Clay, the Secretary of State, calling the attention of the United States to the object of uniting the Atlantic and the Pacific Oceans by a canal through the province which he represented. He assured the Secretary that his government if placed in different circumstances would not part with the least portion of the distinguished honor of executing a work of such importance to the prosperity of the two worlds, the omission to construct which, he said, ought to fill with shame the previous government of his country. But 'the Republic of the Center was in the first moments of its existence, and nothing would be more grateful to it than a co-operation by this generous nation, whose noble conduct has been a model and a protection to all the Americas; it would be highly satisfactory to have it a participator, not only of the merit of the enterprise, but of the great advantages which that canal of communication must produce, by means of a treaty, which may perpetually secure the possession of it to the two nations.'

* The remainder of this chapter is quoted from MSS. of Prof. J. E. Nourse, U. S. N.

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"This overture, which had been occasioned by propositions to the Republic of the Center from Messrs. Barclay & Co., of London, and from merchants of the United States, asking, each, for a concession, was immediately entertained with interest by the President; and Mr. Clay, as instructed, replied to the minister that in view of the importance of a work that would form 'a great epoch in the commercial affairs of the whole world,' a newly appointed chargé d'affaires, Mr. Williams, would investigate with the greatest care the facilities which Nicaragua offered, and remit the information he acquired to the United States. It would be then necessary to consult Congress. The only trace, however, of information which appears to have come from the envoy was the following extract from a letter of Mr. Williams, chargé d'affaires of the United States to Central America, to Mr. Clay, dated 24th November, 1826: 'I met with Mr. Cañaz. He returned to the United States by the river San Juan and Lake Nicaragua. He entertains no doubt of the practicability of the contemplated canal.'

"In regard to the overture made by the minister from Nicaragua, Mr. Squier remarks that—'Although the administration of Mr. Adams did not at once fall in with the proposition, this was not from want of interest in it, but simply because the Government did not wish to commit the country to any specific course until the feasibility of the enterprise and the leading facts concerning it should be better known and understood.'

"The principles on which the work should be executed had been announced by Mr. Clay in his letter to the commissioners of the United States to the famous Congress of Panama. Mr. Clay said: 'A canal for navigation between the Atlantic and Pacific Oceans will form a proper subject for consideration at the congress. That vast object, if it ever should be accomplished, will be interesting in a greater or less degree to all parts of the world; but especially to this continent will accrue its greatest benefits; and to Columbia, Mexico, Central America, Peru, and the United States more than to any other of the American nations. What is to redound to the advantage of all America should be effected by common means and united exertion, and not left to the separate and unassisted efforts of any one power. * * * If the work should ever be executed so as to admit the passage of sea-vessels from one ocean to the other, the benefits of it ought not to be exclusively appropriated by any one nation, but should be extended to all parts of the globe, upon the payment of just compensation or reasonable tolls.' The canal was thus, in Mr. Clay's judgment, to be executed by the parties most interested and to be under their control, but not therefore exclusive.

"In the same year, Don Guadaloupe de Vittoria, the President of the Mexican Confederation, caused a reconnaissance of the Isthmus of Tehuantepec to be made. It was a brief but decided report which the President received from General Don Juan Orbegozo, the officer appointed for this purpose; the survey was carried out with confessedly imperfect instruments, and contributed little to the work. The report stated that 'the canalization of the Isthmus was problematical and gigantic; and the roadstead of Tehuantepec was being more and more abandoned daily by the ocean.' A commission appointed on the same date with that of Orbegozo, by the separate State of Vera Cruz, reported through its chief, Don Orteo Ortiz, upon the bar of the Coatzacoalcos, and this in connection with a plan for a railroad across the Isthmus.

"In the years 1828–'29, under a commission from General Bolivar, President of the Republic of New Granada, Mr. John A. Lloyd, with the assistance of Mr. Falmarc, a Swede in the Columbian service, made a reconnaissance of the narrowest part of the Isthmus of Panama, with a view chiefly of ascertaining a route for land communication, and incidentally to determine the difference o level between the two oceans. A partial survey of this part of the Isthmus had been ordered by the Spanish court as early as 1528, the intention being to commence a small artificial canal at Cruces, but until the survey of Lloyd neither the relative height of the two oceans, nor the elevation of the highlands between, nor the geographical points of the Isthmus had been determined with any degree of mathematical accuracy. Lloyd's papers were communicated to the Royal Society of London, through Colonel Sabine. They will be found in part in the Philosophical Transactions for the year 1830, from which they are quoted, and in the Report of the House Committee (H. R. 145), 1849. He recommended, as a substitute for the old Porto Bello road, a new line from the Bay of Limon, essentially that of the existing railroad; and in reference to the relative level of the two oceans reported, contrary to the belief entertained up to that time by almost

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all minds, except such as that of Humboldt, that the mean height of the Pacific at Panama is but 3.52 feet higher than that of the Atlantic at the port of Chagres.

"The next efforts for an interoceanic work were based upon propositions made by an association in the Netherlands, under the special patronage of the King. September 21, 1830, a plan which had been agreed upon with General Verveer, the plenipotentiary of the King, was ratified by the Congress of Central America. The chief features of this contract were as follows: The canal to be opened on the same terms to all nations at peace with Central America, but armed ships were not to pass without express consent, and this never to be given to a flag at war with another nation. The Government was to use its utmost efforts to have the neutrality of the canal and that of the ocean to a certain extent around its termini recognized by all the maritime powers. No charge was to be made for the land used by the canal or for the raw material necessary for its construction. The work was to be of sufficient dimensions to admit the largest ships. The execution of the canal was to be entirely with and at the expense of the contracting parties. The interest on the capital expended was permitted to be 10 per cent., with a mortgage on the lands on both sides as security for capital and interest. The rate of tolls was to be regulated by the Government and the contractors jointly, but always in such a manner as to give the canal a decided advantage over Cape Horn. In respect to navigation and commerce generally, the Netherlands to be put on an equality with the United States.

"This concession, modified and largely extended, was ratified by the Congress of Guatemala. December 18, 1830. A copy of the full 'decree' was communicated to Mr. Van Buren by Mr. Henry Savage, United States consul at Guatemala, who stated that he had represented to the parties the impolicy of certain conditions which conveyed to the Dutch Company the rights of the coasting trade. The 'decree' will be found in full in Report No. 145, second session, Thirtieth Congress, together with an extract from a letter from Mr. Livingston, Secretary of State, dated July 20, 1831. The chief of Mr. Livingston's instructions in this letter to Mr. Jeffers regarded three points, viz:

"1. That he should represent to the Government that the United States must be entitled to all advantages accorded to other nations.

"2. That if the grant to the Dutch Company should not be completed, he should endeavor to secure for the citizens of the United States, or for the Government itself, if Congress should deem the measure proper and constitutional, the right of subscribing for the stock.

"3. That he should procure and transmit any surveys, estimates, plans, or other information relative to the work which would enable the United States to judge of the feasibility of the canal.

"This whole movement, however, failed. The revolution in Belgium came on, and the subsequent separation between that state and Holland put an end to the propositions which have been named. Consul Savage, in a letter to Mr. Van Buren, refering to this revolution, said: 'All concur here, and every one seems tacitly to look forward to the United States for the completion of this grand project. They say that the United States, identified in her institutions with this Government, is the only power that ought to have the preference.'

"Two years later endeavors were made to renew the negotiations with Holland, and Nicaragua passed resolutions agreeing to the propositions of the Dutch envoy, but nothing was accomplished.

"It appears from the voluminous document transmitted March 13, 1838, by President Jackson, through Mr. Forsyth, to Hon. C. F. Mercer, chairman of the Committee on Roads and Canals, of the House of Representatives, that during the previous four years new interest had been awakened in the matter of the canal. Mr. Mercer's report, made March 3, 1839, was in answer to a memorial from Aaron Clark, Mayor of New York, W. A. Duer, H. Radcliff, and others of that city, and from Matthew Carey, and other citizens of Philadelphia, praying the aid of Congress in the construction of the canal.

"Mr. Mercer, in the begining of his report, said: 'It is obvious that if the contemplated communication from sea to sea be practicable, the nation which has the right to appropriate its exclusive use to itself might lawfully control the richest commerce of the world, or prescribe to all other nations the terms upon which they be admitted to share its enjoyment. The policy is not less apparent which should prompt the United States to co-operate in this enterprise liberally and

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efficiently. * * * If other considerations did not prompt this decision, it should suffice for its confirmation to contrast the continuous voyage of the same vessel across the two oceans, divided by the Isthmus, with the transshipment of a heavy cargo between vessels of equal burden, and the intervening expense of land transportation, double port duties, and commissions, added to the damage of shifting and exposing very valuable commodities to waste and depredation. The United States, whose territory extends from the Atlantic to the Pacific, cannot but regard with solicitude any enterprise which, if practicable, will so greatly approximate their eastern and western frontiers.'

"The committee closed their report by recommending to the House of Representatives the adoption of a resolution similar to one which had passed the Senate March 3, 1835, and which read as follows:

"'*Resolved*, That the President of the United States be respectfully requested to consider the expediency of opening negotiations with the Governments of other nations, and particularly with the Governments of Central America and New Granada, for the purpose of effectually protecting, by suitable treaty stipulations with them, such individuals or companies as may undertake to open a communication between the Atlantic and Pacific Oceans by the construction of a ship-canal across the Isthmus which connects North and South America; and of further securing forever, by such stipulations, the free and equal right of navigation of such canal to all nations, on the payment of such reasonable tolls as may be established to compensate the capitalists who may engage in such undertaking and complete the work.'

"In compliance with that resolution, President Jackson appointed, May 1, 1835, Mr. Charles Biddle, of Philadelphia, a special agent to proceed to the Isthmus, for the purpose of making all necessary inquiries in reference to the work. Mr. Forsyth's letter of instructions directed him to proceed by the most direct route to the port of San Juan, Nicaragua, and, ascending that river, cross thence to the Pacific, making all inquiries as to plans, surveys, and estimates, and procuring at Guatemala copies of all public documents regarding the subject. From Guatemala he was to proceed to Panama, make as thorough an examination as possible of the route there, and at Bogota, obtain copies of public documents in reference to a projected railroad, and especially any information in regard to a concession said to have been made by the Government of New Granada to a certain Baron Thierry. Furnished with a circular letter to all the United States consuls in the countries referred to, and also in Mexico, Mr. Biddle set out on his journey, but, as it appears from the difficulties of obtaining at that time direct conveyance to San Juan, Mr. Biddle went first to Panama, never reached Nicaragua, and died soon after his return to the United States, 1836, without making any full report.

"In regard to the concession to Baron Thierry, he had reported from Bogota that the Congress of New Granada had made a grant to that person of an exclusive privilege of constructing a canal to connect the waters of the Chagres and Rio Grande. The Baron, however, never viewed the ground through which it was contemplated it should pass. He had no pecuniary resources or friends engaged in the project, and the real purpose of his application for the concession appeared, undoubtedly, to have been to obtain by that means an acknowledgment by the State of New Granada of his title of sovereignty over the island of New Zealand. The sketch of his application had contained this title, and he had vigorously opposed its being omitted from the grant. It was, at the time of Mr. Biddle's writing, considered a dead letter, and was afterwards annulled.

"The two points of singular note in this matter are: the act of the Government of New Granada in granting a concession to such a mere adventurer, and the obtaining by Colonel Biddle, while at Bogota, a grant for himself and friends for the construction of a railroad across Panama. Thierry had been one of the ushers of Cambridge University, England, and when some of the natives from New Zealand had been its visitors they had elected him sovereign, confirming their act by tattooing his title on his body. After disdaining the grant from New Granada, passing over toward his supposed territory, he was refused a landing at Tahiti, at the instance of Commander Fitzroy, H. M. S. Beagle. The chiefs of New Zealand had also assembled in council and pronounced him a foreign enemy. Colonel Biddle's act was entirely disapproved by the United States, through Mr. Forsyth, who caused a protest to that effect to be made at Bogota, when his mission was again represented to have been for the purpose of collecting information only.

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"While Mr. Biddle was absent from the United States on his mission, General Morazin, President of Central America, in 1836 employed a Mr. John Bailey, R. M., who had long resided in the country, to make a survey for a canal. Bailey made a survey of the narrow isthmus intervening between Lake Nicaragua and the Pacific, and also some observations on the river San Juan. These observations and his proposed route from the lake to San Juan del Sur were thus criticised by the late Admiral Fitzroy, R. N., before the Royal Geographical Society of London, 1850: 'This favorite idea of cutting a canal from the lake to the nearest point on the ocean is checked by the fact that a range of hills intervenes, through which it would be necessary to tunnel, and there is no sheltered harbor where numerous shipping may anchor. San Juan is only 1,100 yards across, open to the ocean swell; the elevation of the proposed tunnel will be at least 120 feet above the lake, and the lowest level over it would be some 600 feet above the sea.' Mr. Bailey made no report upon the river San Juan.

"Within the same period, by a convention between the States of Nicaragua and Honduras, M. Rouchaud was authorized to conclude an agreement for the formation of a canal company in France, but no results attended his efforts or those of the Bishop of San Salvador, sent on a like errand by Guatemala to Rome. The same is true in regard to the contract entered into with Nicaragua, which had become an independent State, between Mr. Holdship and Mr. Soulé, agents for a company formed in New York and New Orleans.

"In 1838 the Government of New Granada, which had continued to lay before the world its offers to grant concessions for a canal, issued a grant to a French house of trade, under the firm of Solomon & Co., with the privilege to construct either macadamized roads, railroads, or canals across the Isthmus. Messrs. Solomon & Co. proposed to build a canal by a newly discovered route, on which the summit level did not exceed forty feet; the canal to require no locks and form an open cut of sufficient dimensions to admit the largest vessels. Nothing practical, however, was effected. No exact levelings, no observations whatever were made, with the exception of some isolated barometrical measurements on an entirely different line from that which had been published, those who had visited the Isthmus having judged the height by simple visual observation.

"June 10, 1843, M. Guizot, prime minister under Louis Philippe, addressed the Chamber of Deputies of France in a speech in which he referred to the consequences of opening a canal across the American Isthmus as involving necessarily the most important results in respect to the commercial relations between Europe and Asia; and he admonished the Chamber that France should not remain an indifferent spectator at a time when Great Britain had already taken a position in Central America on all the points where the passage might be cut off. He made the fair conclusion that such a work as an interoceanic canal across America could be satisfactorily accomplished only by the cordial co-operation of the great maritime powers.

"The French Government sent M. Garella to explore a route which had been most favorably represented by the agents of Messrs. Solomon & Co., but he found the report of that company wholly unfounded. He made a full examination of the route from Limon Bay to Panama and ascertained the lowest elevation of the divide to be 120 meters in place of the 12 only represented by the agents of Solomon & Co., and for a canal admitting ships of 1,200 tons, a tunnel of 5,350 meters. The full cost of the work would be nearly 200,000,000 francs.

"As far as regards any action on the part of the United States or its citizens for interoceanic communication, it was directed during the next ten years to the opening of a route across Panama, resulting in the negotiation of a treaty by which the neutrality of the Isthmus was guaranteed by the United States, and New Granada conceded free transit. Under this treaty, the first steps towards which would appear to lie in Mr. Biddle's mission, the existing Panama Railroad Company was organized.

"In 1844 Señor Don Francisco Castellon, the minister from Nicaragua to France, entered into a fruitless contract with a Belgian company, and in 1846 Marcoleta, chargé d'affaires from Nicaragua to Belgium, entered into a like unfulfilled contract with Louis Napoleon Bonaparte, then a prisoner in the fortress of Ham.

"In 1848 it was evident that the war between the United States and Mexico would secure at its close a large extension of territory to the former power. The certainty, therefore, of the development of new and valued interests arising out of this event awakened both in the United States

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and abroad new investigations. In Executive Document 69, First session, Thirtieth Congress, it will be found that the State Department instructed Mr. N. P. Trist, its agent in Mexico, that, in arranging the terms of a treaty of peace, 'in place of the $15,000,000 offered for an extension of the United States boundary over New Mexico and Upper and Lower California, he might increase the amount to any sum not exceeding $30,000,000, to secure the right of transit across the Isthmus of Tehuantepec.' This offer was, however, absolutely rejected by the Mexican Government.

"In the year following, under contracts respectively with the Governments of Nicaragua and New Granada, sanctioned by treaty stipulations, attention was directed anew toward these routes. The first success was made by the Panama Railroad, in the year 1849. The route for that road was laid out by engineers under Col. George Hughes, of the United States Topographical Corps, who found a yet more favorable line than that discovered by Messrs. J. S. Stephens and J. L. Baldwin, to whom is due the credit of securing this route. The road was at once in process of construction. The late Admiral Fitzroy, in his paper before alluded to, said of this work that 'its progress was such only as United States men could have accomplished in defiance of all obstacles.'

"In Nicaragua, by the agency of Mr. E. G. Squier, chargé d'affaires of the United States, under a treaty of commerce and friendship, a very liberal charter between the Government and the American Atlantic and Pacific Ship Canal Company, of New York, was ratified August 27, 1849. Under this contract Col. O. W. Childs made an instrumental examination of a route from the port of San Juan to Brito, closely examining the short line on the Pacific side. The judgment of engineers in England was not, however, sufficiently encouraging to secure in England the capital needed to begin the work. The company therefore lost its concession from Nicaragua, but shortly after obtained the use of their conceded privileges for the purposes of local trade and the transit of passengers, of whom a very large number passed over this rough route to the gold fields of California and its industries.

"The occupancy of the Mosquito territory by Great Britain, and the consequent disturbed relations of the parties interested, until the conclusion of the well-known Clayton-Bulwer treaty, April 19, 1850, had threatened for a time the entire prevention of any work in this region.

"In 1853, under the Gadsden treaty, the right to construct a railroad across Tehuantepec was granted by Mexico, but the uncertain political state, and the terms of the grant, deferred for some years the practicability of securing even such an improvement of communication."

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CHAPTER IV.

INFLUENCES WHICH AFFECTED THE DEVELOPMENT OF THE PROBLEM.

While the grandeur of the problem always secured for it special students, its development necessarily depended upon its practical character, and a widespread attention to its solution could not be attracted until this element was manifested. In the acquisition of California by the United States, the discovery of its gold fields, and those of Australia, and in the development of the Pacific coast of North America, are to be found the chief causes which led to an awakened interest in its reality, and an increased appreciation of the importance of its solution. The labors of Paterson, Humboldt, and a host of others, to impress upon the world the importance of the subject were feeble and ineffectual when compared with the influence of the magic word "gold."

In the California gold lies the potent charm which brought the Panama Railroad into existence; and the necessity which placed the iron-horse upon the Isthmus awakened thought to the increased practical value of a ship-way, and, as a consequence of the attention thus attracted, there resulted a remarkably active attack upon the interoceanic canal part of the problem.

The era which followed is noted not only for the activity displayed, but also for its being, with the exception of Moro's instrumental examination of Tehuantepec and Garrella's survey of Panama in 1843, the beginning of the era of exact determinations. In Hughes' survey for the Panama Railroad, 1849, Childs' survey in Nicaragua, 1850–'51, and the Barnard-Williams survey in Tehuantepec, 1851, are to be found the first data approaching accuracy and fullness.

While the new interest thus excited extended to studies of different portions of the American Isthmus, the field of greatest activity was in Darien and its vicinity. This was due to several reasons. The other isthmuses each possessed a single route, subject to modification. Darien held forth promises in at least six routes. The Tehuantepec, Nicaragua, and Panama routes were known to present grave obstacles, while those in Darien, being unexplored, were more attractive to the enthusiast, for the very reason that facts, particularly stubborn ones, were few regarding their character, thus leaving an unrestricted path for the most hopeful expectations. Other important reasons are to be found in the attractions presented by its narrowness, its excellent harbors, the very mystery which ruled its interior, and, finally, in the hope held forth by Humboldt that Darien held the secret of the hidden way.

The eagerness with which a word bearing upon this country was seized, if uttered by any one having the least claim to the public ear, is an evidence of the general ignorance respecting it; and with no other motive than to give a measure of this ignorance Humboldt's misconception will be noted. The primitive idea of the existence of a strait between the two oceans was naturally followed by that of a break or pass in the Cordillera, which could easily be reduced to an artificial strait. Of such passes there was no lack in the legendary lore of the country, and the very ignorance respecting its interior aided the notion of their existence, and permitted free play to the imagination respecting them. One of them was placed at the headwaters of the Napipi River, and the following extract from Humboldt's Personal Narrative of Travels shows how fully convinced he was of its existence; and the fact, developed by governmental surveys, that the Cordillera is unbroken, that its altitude varies from six hundred to two thousand feet in this vicinity, shows how far wrong he was:

"The erroneous idea which geographers, or rather drawers of maps, have so long propagated, of the equal heights of the Cordilleras of America, their prolongation in the form of walls and continued ridges, and, finally, of the absence of any transversal valley crossing the pretended central chain, has caused it to be generally believed that the junction of the seas is an undertaking of greater difficulty than there has been hitherto reason to suppose.

"It appears that there are no chains of mountains, not even a ridge of partition, or any sensi-

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The Isthmus of Darien and the adjoining province of Choco, in the valley of the Atrato, showing the different localities that have been made the subject of study or exploration.

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ble line of demarkation between the Bay of Cupica, on the coast of the South Sea, and the Rio Naipa, which empties itself into the Atrato, fifteen leagues above its mouth. A Biscayan pilot, M. Gogueneche, called the attention of government to this point in the year 1799.

"Persons worthy of credit, who have made the passage with him from the Pacific sea to the embarcadere of Naipi, assured me that they saw no hill in that isthmus of alluvial earth which they were ten hours in crossing. A merchant of Carthagena, South America, deeply interested in all that regards the statistics of New Granada, Don Ignacio Pombo, wrote to me in the month of February, 1803: 'Since you ascended the Rio Magdalena to Santa Fé and Quito I have never ceased to take information respecting the Isthmus of Cupica. There are only from five to six leagues from that port to the embarcadere of Rio Naipi, and the whole territory is a plain (*téreno enteraménte llanos*).' From the facts I have mentioned, it cannot be doubted that this part of the northern Choco is of the highest importance for solving the problem under our consideration; but in order to form a precise idea of this absence of mountains at the southern extremity of the Isthmus of Panama, we must bear in mind the general outline of the Cordilleras.

"The chain of the Andes is divided at the second and fifth degrees of latitude into three chains, and the two longitudinal valleys that separate those chains from the basins of the Magdalena and the Rio Cauca.

"The eastern branch of the Cordilleras inclines towards the northeast, and joins itself by the mountains of Pamplunis and Guita to the Sierra Nevada de Merida and the chain of the coast of Venezuela, and the intermediate and western branches of Quindis and Choco run into one another, in the province of Antioquia, between the 5° and 7° of latitude, and form a group of mountains of considerable breadth, stretching by the Valle de Osos, and the Alto del Viento, towards Cazeres, and the elevated savannahs of Tolu.

"Farther west, in the Choco del Norte, the mountains lower to such a degree that, between the Gulf of Cupica and Rio Naipi, they disappear altogether."

In support of this theory of a break of the Cordilleras in the vicinity of Cupica Bay, it is stated by Watts that an enterprising Spanish merchant opened a road for the transportation of merchandise from the head of canal navigation in the Napipi to the Pacific; and again, that in 1820 a boat of the Chilian war vessel Andes was hauled from the Pacific to a navigable point on the Napipi in ten hours. There is no doubt of there having been a mule road or trail, as evidences of such remain to this day, and the fact of the transportation of the Andes' launch is attested by Cochrane in his Travels in Columbia; but the element of time is altogether out, as it would require nearly all of the interval stated to perform the journey unimpeded. The inference was that the transportation of the boat was an easy matter, whereas it must have been a labor requiring much time and toil.

Other localities of the Isthmus disputed with the Napipi for an almost uninterrupted water communication across, having but an insignificant carry from canoe navigation on one slope to that on the other, and that the canoes were hauled over this short distance with ease. Undue importance was attached to this performance, as the fact bore no evidence to the altitude of the *atravesia*, or carry, above the level of the sea, it being possible to transport light canoes over high ridges.

These legends received additional value from Humboldt's reference to some of them in pointing to the Isthmus of Darien and the valley of the Atrato as the proper field for future exploration. In the absence of a personal experience of the country he was forced to rely upon the statements of others, and gave such as influenced him to look in that direction for what they were worth; and while not pretending to write authoritatively of this region, his general reputation was considered and undue weight given to his utterances, which have been quoted again and again, as though possessing the full value of a personal observation made by the illustrious savant.

For the reasons given, and allured by the "will of the wisp," the break in the Cordillera, Darien became the scene of a marked activity which was participated in by citizens of England, France, and the United States; but to those of the latter country is due the honor of a more active exploration and of the accomplishment of better results. Individual efforts, however, availed but little; in fact a prominent feature of these early expeditions is embodied in the word "failure." From the time Columbus abandoned its shores, after a vain search for the strait, until

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within the past decade, of the many attempts which have been made to explore Darien and its vicinity, but few were attended with any success; the majority of them, conducted by enthusiastic searchers after a route which would be theirs, were not only unsuccessful, but, what is worse, furnished results which were in fact the flimsiest of illusions, and only added a multitude of contradictions to the existing uncertainties.

It is natural, in a region which places her secrets beyond the reach of all methods save those of exact science, that the explorer, with a concession in his pocket, or with a desire to render his name famous, should be so far carried away as to overcolor apparent advantages, and not only underestimate but be entirely blind to disadvantages which are really much more apparent. Such fanciful results, presented to the world through the press and learned societies, acquire a certain dignity which has its influence in extending the errors.

Efforts of this character resulted in widely conflicting statements, and the greater the number of such explorations the greater became the number of uncertain elements in the problem which had to be eliminated by accurate surveys. Even after these had been executed and the results given to the world there still remained champions of visionary schemes, adhering so tenaciously to them that to have been honest in their convictions they must have been invincibly ignorant of facts. It is for their negative value, and to the persistency on the part of pseudo-experts in advocating such routes, even to a late day, acquiring for them an unmerited importance, that it is necessary to record these futile attempts at exploration.

Among these individual efforts, however, those instituted by Mr. F. M. Kelley, of New York, stand forth prominently as being of great value; and it was through his exertions that the United States Government interested itself in making an official survey of the Truando route, previously explored by his direction. This was in 1857, and the interest thus developed would no doubt have been continued were it not for the unsettled state of the country, soon followed by the War of the Rebellion.

THE DAWN OF LIGHT ON THE ERA OF SYSTEMATIC EFFORT.

The leading students of the problem, seeking its full and not partial solution, sought this end by recommending a system which it was expected would develop all the elements involved in the height and character of the Cordilleras. Humboldt once gave an opinion upon this in substance thus: "Do not waste your time and money in running experimental lines across. Send out a party fully equipped, which, keeping along the dividing ridge from the Atrato Valley down the whole length of the Isthmus as far as the Cordillera of Veragua, will give you a complete knowledge of the hypsometrical and geological condition of the dam that obstructs the travel and commerce of the world." V. A. Malte Brun, editor of the publication of the Société de Geographie, of Paris, in 1866, freely expressed himself in the same way, after a thorough study of what had been done. "It is to be desired," he writes, "to have an exploration from the Atlantic Ocean, having for its object the whole Cordillera from the Gulf of San Blas to Cape Tiburon. True, that would require energy and money."

To these requirements an eternity would have to be added, for although the plan is simple and seems easy of execution, it is not so, and is in reality impracticable. To ascertain the elevation of the crest of the dividing ridge at all points would, of course, involve the necessity of following it throughout its length, but owing to the physical characteristics of the country this is so difficult as to be almost impossible. This was demonstrated during the Darien survey of 1870–'71, when an attempt was made to find the elevation of the Cacarica Pass, a few miles to the northward of the point where the main line of survey crosses the Cordillera, by running a line of levels along the crest of the divide until the depression was reached. Nearly three weeks were consumed in this attempt, and the actual progress made along the crest of the divide was less than a mile. This slow advance in the desired direction was due to the density of the forest, in which the vision was limited to a radius of a few feet, and to the repeated changes in direction of the dividing ridge. Owing to these changes of direction the line of survey was constantly running off from the divide to its spurs, and it often happened that the labor of several days of a supposed advance was wasted on a spur before that tantalizing fact would be made manifest. Unable to judge how much of this

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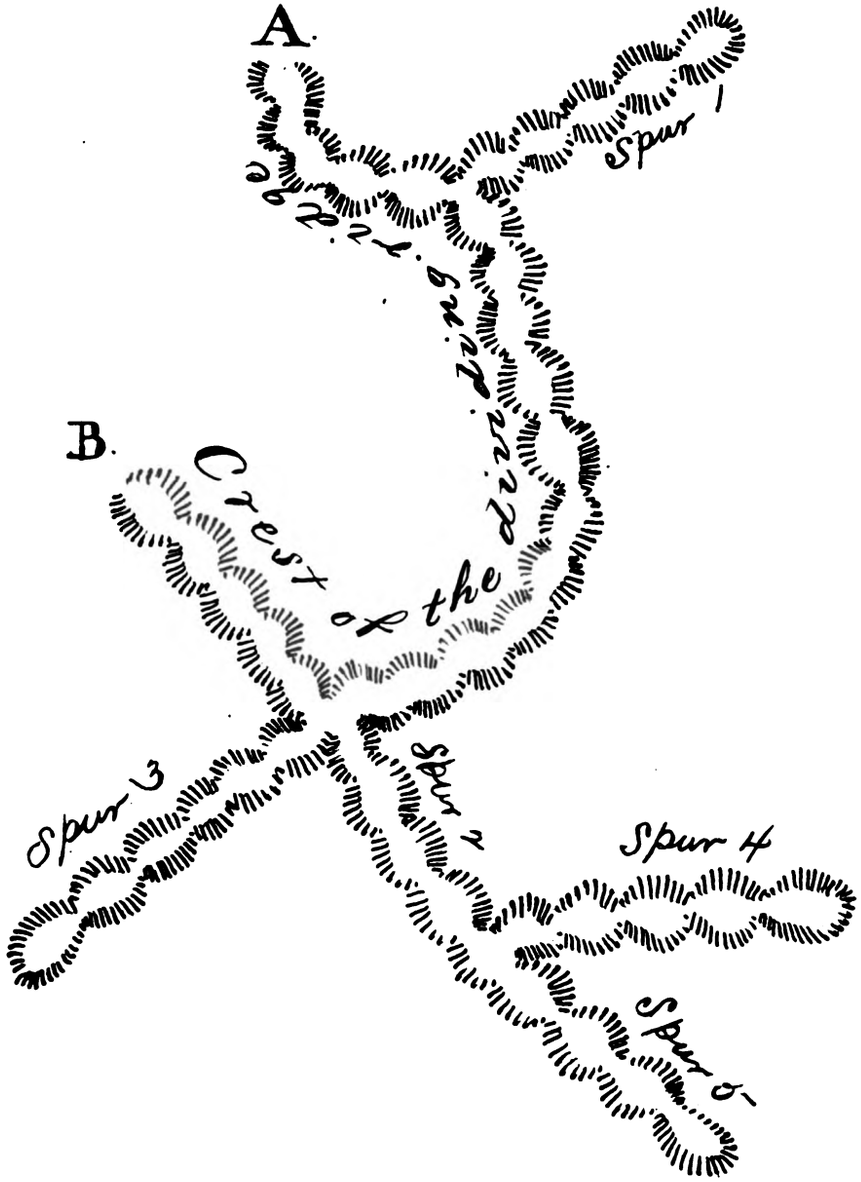

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work was on the spur and how much on the divide, or, in other words, at what point the divide had been lost, it was necessary to go back to a point known to be on the divide, and from there undertake a system of laborious and wearisome reconnaissances to ascertain the locality of the divide further on. Several days at a time were frequently spent in such a search, and then, after following it a short distance, the former experience would be repeated.

The difficulty of keeping the "divide" can be better understood by referring to the accompanying sketch. Considering the ridge and spurs raised so as to be detected by the touch, it will be clear that with closed eyes, and no previous knowledge of the tracing, a person commencing either at A or B to follow the ridge would be sure to run off by the spurs 1 or 3.

Fortunately it is not necessary to follow the crest of the divide to learn of its depressions, as the watercourses on either side lead to them. *The bed of a stream or river furnishes the line of lowest levels in the basin drained.* This axiomatic statement formed the basis of a plan for systematic explorations developed by Lieutenant (now Rear Admiral) Ammen nearly twenty-five years ago, and in the history of the problem there is no effort fraught with such great and practical results. It was the early dawn of the light which now rests on the problem, and has linked its author's name permanently in a most honored position to the grandest project of modern civilization.

Reading with a melancholic interest the account of the Derien expedition under Lieutenant Strain, U. S. N., in 1854, Admiral Ammen was attracted by a paragraph which seemed to point to a strong probability of the existence of a low line of levels between waters adjacent to Caledonia Bay and the waters of the Sucubti at the point reached by Strain after three days' travel down that river. When encamped on an island where it seems the river was no longer a mountain stream, Strain supposed that he heard the evening gun of the Cyane, the vessel he had left four days previously. Assuming as a fact that the evening gun had been heard, it seemed to Ammen an indication of a low line of levels lying between the vessel and the encampment. In explanation he stated that "every observer who has stood on a mountain peak has doubtless been struck with the many sounds which have reached his ear, coming up from the valleys beneath with surprising force and distinctness; the song of birds, the lowing of cattle, and the voices of men, curiously commingled, fill the air; the line of least resistance carries sound in a constantly increasing upward angle, never, of course, to come down again to its former level."

The loss of life and the absence of instrumental results in the Strain expedition, and the supposition of Strain, when encamped for the first time and near the crest of the divide, that some of his party who had separated "had followed up the valley which he felt sure existed on his left," together with the supposed hearing of the evening gun before alluded to, led Ammen to consider how to overcome the difficulties of exploration in that country. Presenting his views to Mr. Toucey, Secretary of the Navy, in 1856, he requested to be furnished with authority and the necessary, but inexpensive, means to examine the Isthmus of Darien. Failing to receive countenance and support, he went to duty on the Pacific Station, and did not return from his cruise until 1860, when he laid the following paper before the American Geographical Society on the 7th June of that year:

* * * * * * *

"It is believed that the learned Geographical Society of New York will readily concede that the topography of Darien is still almost unknown, and that it presents a question whose solution is much desired, namely, the possibility of constructing a ship-canal between the two oceans.

"The various expeditions to that region have furnished only partial maps of any accuracy; and, in view of the very incomplete results, it may be asked whether it is not possible to explore thoroughly a district of such limited extent. Nevertheless, these expeditions have furnished very useful information touching their causes of failure, and it would be wanting in justice not to acknowledge particularly the hardships and perils of that under Lieutenant Strain, U. S. N., in 1853, and the endurance and courage shown by himself and others. To profit by the experience of those that have preceded, in the organization of another expedition, may insure its success.

"Although there are facts which appear to favor the existence of a low line of levels between the two oceans, a great object would still be gained were the reverse fully established. Capitalists will entertain seriously this project of constructing a ship-canal between the points already pronounced practicable only after it has become a certainty that the best line of levels has been determined.

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"Colonel Totten, the able superintendent of the Panama Railroad, pronounces a line practicable for a ship-canal near that of the railroad. The whole territory from the Isthmus of Panama to that of Darien is as yet so imperfectly known that the character of much of the topography is only conjectured, and therefore may present yet more favorable conditions for the construction of a ship-canal than that above mentioned. It will be borne in mind that the region alluded to has never been entirely under the dominion of the white man, and that at this time no stranger is permitted to traverse or reside in the country.

"The maps made by the Jesuits some two centuries ago show at least three points where the waters flow into the Pacific from the south and west slopes of mountains which rise immediately on the borders of the Caribbean Sea. The expedition of Strain verifies one point; and with the summit level so near one terminus the possibility of finding gaps in the mountains, or of there being favorable localities for tunneling, will be readily admitted.

"The account published of Strain's expedition states that finding a mountain path which they followed on leaving the bed of the Caledonia River, on the Caribbean slope, his party separated, and that in the afternoon he halted and fired guns to indicate his locality, and at this point Strain speculates on the probability of the missing men having followed up a valley which he felt sure was on his left. The waters here flowed into the Pacific. The next day they followed a streamlet, and soon reached 'a considerable river,' down which they followed. That night at their encampment they supposed they heard the 9-o'clock gun of the Cyane, the sloop of war they had left four days before.

"A tradition has long existed that the Indians go from ocean to ocean with their canoes. If such is the fact, the portage is no doubt short and the hills low. There is no positive knowledge in relation to the Isthmus of Darien which precludes the existence of a low line of levels. On the other hand, we have the facts before stated, showing that the summit level borders the Caribbean, and that Strain was convinced that he heard the evening gun of the Cyane, which in itself, if true, appears to make the existence of a low line of levels almost a certainty, for he was then at a point where the river Sucubti was no longer a mountain stream. It is not believed possible that the sound of a gun at such a distance will pass over an unbroken mountain chain and descend into the valley below.

"Having been in the forests of Central America, I appreciate the difficulty of a proper reconnaissance, such as would settle the practicability of a route for a ship-canal or the reverse. I beg, therefore, that the learned Geographical Society will pardon my zeal, if not presumption, in offering a few suggestions in relation to the organization of a party and to the mode of operations which may be adopted for the attainment of the proposed object. The journals of the expeditions alluded to indicate their defective organization and reveal many causes of failure; but as the object of this paper is to acknowledge and profit by the information received through them, we will pass at once to the consideration, in a practical form, of further explorations.

"Twenty young men accustomed to labor and to the use of the ax and the rifle, provisioned with a light supply of pemmican and of parched corn, and supplied with proper arms, axes, fish-hooks, &c., and provided with a portable boat, would be able to reach the Pacific with ease and to live in these forests without the possibility of suffering from want of food. In our country the organization of such a party would be an easy matter. Once upon the ground, they could proceed as follows:

"1. Aided by boats, to make a geographical determination or unification of the coast line, if found correct, from the Bay of San Blas to the port of Santa Maria Vieja, a distance of some 120 miles; also making examinations and reconnaissance of harbors and inlets of which no charts exist.

"2. A thorough examination of all the considerable ravines to the summit level of the Coast range, chaining the distances, or using the sextant by measuring the height of the measuring staff, or by the use of a micrometer telescope, taking also lines of levels and compass courses. Where mangrove swamps exist it would be necessary to examine with particularity the hard ground inside of them, as a great waste of *débris* from a valley would probably cause a swamp in that almost tideless sea.

"3. On the Pacific slope, to ascend the various arms of rivers falling into the Bay of San Miguel,

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as high as possible, taking lines of levels, courses by compass, distances by micrometer telescopes, and from time to time making geographical determinations; also to make the same observations on the river Chepo, between the headwaters of which and the streams falling into the Gulf of San Blas there is great reason to believe may be found a most favorable point for the construction of a ship-canal.

"4. To observe with particular care, on ascending these rivers, localities where a near approach of massive hills might afford the possibility of the formation of artificial lakes; also the superficies that may be overflown, as well as the height and extent of the embankment required. It is not at all improbable that large districts could be flooded with little labor, and the distance shortened very materially over which it would be necessary to make excavations.

"These observations, when complete and plotted, would form a skeleton map which would show the canals dug by nature, and their relative depths, and would point out also the bearings and distances of the various localities with reference to each other. Thus it would be made easy to connect the watersheds of the two oceans by the most practicable line of levels between any desired points, and to consider the feasibility of a tunnel, if necessary, as will probably be the case in the construction of a ship-canal.

"The forests are so interminable, so matted together by vines and choked by undergrowth, that once beneath their foliage it is literally groping in the dark. The exploration of even a few miles is attended with much labor; a fact attested by all who have actually tried it. As a primary step to a satisfactory determination of the topography of the Isthmus of Darien, a skeleton map, as above proposed, appears to be an actual necessity.

"The boats now in use on the Chagres River would be well adapted to exploring the river alluded to; and by the use of two of them, carrying up lines of levels would not be a slow operation. As they are usually propelled by use of poles, and draw but little water, they can ascend almost any stream not a mountain torrent.

"It would be essential to cultivate the best relations with the coast Indians, and have them communicate the fact to their friends in the interior. By judicious conduct towards them, their repugnance to visitors might be overcome, and perhaps even their co-operation secured; at all events, after awhile they would feel assured of the good faith and kind disposition of the explorers and finding our people never off their guard, the natives would feel the danger of initiating hostilities.

"The discussion of the subject by your learned society cannot fail to promote a disposition on the part of our Government and that of other Governments interested in extending commerce to set at rest all doubts through the organization of such expeditions as will be able to effect the object, namely, the determination of the topography of the Isthmus of Darien, with reference to the practicability of constructing a ship-canal between the two oceans."

This paper was read before the American Geographical Society during a period of great political excitement, which, as time passed, grew sectional and more intense until the following spring, when our country found itself in the toils of civil war, which precluded any action upon the valuable suggestions presented.

When in Washington, in the winter and spring of 1866, Admiral Ammen had frequent opportunities for discussing the canal question with General Grant, whose life he saved when a boy, and for whom he entertained a high regard and friendship. In these studies an old Spanish map was used, and, at General Grant's request, Rear-Admiral C. H. Davis, Superintendent of the Naval Observatory, had it enlarged, and the correct coast lines and other parts of the topography better known were substituted. The interest which the General took in this important subject is shown in the following letter:

"HEADQUARTERS ARMIES OF THE UNITED STATES,
"*Washington, D. C., July 7*, 1866.

"DEAR SIR: Your letter of the 3d July, alluding to the interest which I have heretofore expressed in favor of a canal to connect the Atlantic and Pacific Oceans is received. I firmly believe the scheme practicable, and if it is, there is no doubt but that in this age of enterprise the work will be done. I regard it as of vast political importance to this country that no European Govern-

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ment should hold such a work. For this reason I have endeavored for the last year to get such a thorough survey made by the Government of the United States, through the territory of the Colombian Government, as would fully determine whether such a project is feasible, not doubting but that on the presentation of such feasibility American capital and an American company, under some treaty that could be easily arranged between the two Governments, would undertake it. * * *

"At the instance of Captain Ammen, U. S. N., and myself, the Secretary of State has put himself in communication with the Colombian Government, with the view of obtaining the authority to make a survey through the territory for the purpose of determining the practicability of an interoceanic canal.

"Very respectfully, your obedient servant,

"U. S. GRANT,
"*Lieutenant-General.*

"Rear-Admiral C. H. DAVIS, *United States Navy.*"

The subsequent indifference shown by Mr. Seward, Secretary of State, caused General Grant to refrain from having anything more to say to him in relation to further examinations of the Isthmus.

Recognizing the value of an official answer to the question whether the Isthmus had been satisfactorily explored and was sufficiently well known to make it possible to decide upon the best location for a canal, General Grant and Admiral Ammen secured the passage of the following resolution, introduced by Senator John Conness, of California:

"*Resolved*, That the Secretary of the Navy furnish, through a report of the Superintendent of the Naval Observatory, the summit levels and distances by survey of the various proposed lines for interoceanic canals and railroads between the waters of the Atlantic and Pacific Oceans; as also their relative merits as practicable lines for the construction of a ship-canal, and especially as relates to Honduras, Tehuantepec, Nicaragua, Panama, and Atrato lines; and also, whether in the opinion of the Superintendent the Isthmus of Darien has been satisfactorily explored, and if so, furnish, in detail, charts, plans, lines of levels, and all information connected therewith, and upon what authority they are based."

In compliance with the resolution, the report was made by Rear-Admiral C. H. Davis, in July, 1866. As the result of his investigation, he reported that the Isthmus of Darien had not been satisfactorily explored, and further that "there does not exist in the libraries of the world the means of determining, even approximately, the most practicable route for a ship-canal across the Isthmus. Our really authentic information amounts to this: That at that part of the American Isthmus where the oceans approach each other nature has supplied harbors of unsurpassed excellence on both sides, and navigable rivers that invite the traveler to penetrate into the wilderness; while on one side she has established a tidal condition in the highest degree favorable to the needs of a commerce which traverses the great seas."

These prominent features of Darien were too important to be disregarded, and as long as its interior remained a *terra incognita* the question of location for an interoceanic canal could not claim a wise determination. Recognizing the importance of filling this gap in our information, Senator Conness obtained from Congress an appropriation for the necessary surveys, and in the latter part of 1869 the first active steps were taken by the United States, through her Navy, to efface this blot upon the knowledge of the world.

In the mean time General Grant had been elected President, and did not fail to take an active interest in the solution of the problem. Admiral Ammen was recalled from the Asiatic Station and appointed Chief of the Bureau of Navigation, Navy Department, and was charged by the Secretary of the Navy with the duty of organizing the surveying expeditions and directing their efforts. He was charged "to give special attention to the selection of the most efficient officers for this work; to look closely to the proper supply of articles of subsistence, and for the best instruments found by experience to be suitable; to formulate orders for his examination and approval; to examine closely the results of surveys; and to supply whatever deficiences might be found to exist for the full investigation and determination of this question."

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Under a resolution of Congress, President Grant appointed a Commission, on March 13, 1872, to study the results furnished by the United States expedition and other reliable sources. This Commission was ordered to consist of the Chief of Engineers, United States Army, the Superintendent of the Coast Survey, and the Chief of the Bureau of Navigation. The officers filling these positions at the time were, General A. A. Humphreys, C. P. Patterson, and Commodore Daniel Ammen. After the appointment of the Commission all orders and instructions for surveys in progress were, in effect, in accordance with its wishes and requirements.

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CHAPTER V.*

THE AMERICAN ISTHMUS: ITS PHYSICAL CHARACTERISTICS, AREA, AND POPULATION.

THE ISTHMUS OF TEHUANTEPEC AND CENTRAL AMERICA, FROM THE COATZACOALCOS TO THE ATRATO.

PHYSICAL CHARACTERISTICS—AREAS—POPULATION—TABLE OF ROUTES.

The distinguished geographer, Carl Ritter, was the first to invite attention to some marked pecularities presented to an eye which rests on a map of the two continents. These are: In each continent a peninsular form, trending southward, either in a mass, as Africa or South America, or in broken peninsulas, as Southern Asia and Europe; secondly, the existence of island groups on the right hand of the southern limits of each land mass, as the West Indies and the Falkland group for America, and Australasia, with the various peninsulas of Southern Asia; and, as a third and more marked characteristic, the narrow neck of land which in each continent joins the land masses and separates two seas—the Isthmus of Africa, Suez; the Isthmus of America, Tehuantepec, and the yet narrower neck joining the two Americas.

The two isthmuses, African and American, themselves strongly contrast with each other. Physically, Suez is a hundred-mile arid depression, of which more than half is on a level with or below the Red Sea and the Mediterranean. But the American Isthmus is for a long extent a ridge of the Cordillera. To cross Suez is to pass elevations scarcely above 50 feet. To cross our Isthmus is to encounter, if in Tehuantepec, the lowest elevation on a practicable line of transit, 754 feet; if in Honduras, elevations from 2,000 to 3,000 feet; if in Panama, the lowest summit level, 287 feet above the mean tide level of the Atlantic.

The American Isthmus exhibits a character more marked than any other on the globe. It presents the distinctive points of a narrow breadth from sea to sea, out of all proportion to its length, with a wide diversity in such narrow limits of physical structure and climate, and consequently of natural products. A glance at the map will impress the first of these points. Measurements on the Isthmus confirm it. From the mouth of the Coatzacoalcos, where the Isthmus joins the expanse of North America, to the Gulf of Darien, where it joins South America, the line is about 1,230 miles. Compare with this the line across Tehuantepec, 143 miles, or from Puerto-Caballos, in Honduras, to Bay of Fonseca, 161 miles; from Aspinwall to Panama, 47½ miles; the mean of these will give for the breadth of the Isthmus but about one-ninth of its length.

Other isthmuses show no such disproportion. They are but from one-fiftieth to one-hundredth of the length of our American neck. They are found between two gulfs or between a sea and a bay. Ours separates the two great oceans. It has been called an immense causeway, separating the seas while uniting the continents. It is to be noted that the Isthmus of Suez is but the center of the old continent; the American Isthmus is the center of the oceans. The opening of navigation through Suez gives a short route inland for Western Europe to the east of the old continent; but open a neutralized strait across Central America, and we open one-half of the globe to the other.

The general trend of the coast line is from west-northwest to east-southeast, presenting on the Atlantic side two marked projections—one, the peninsula of Yucatan, which, with Florida and Cuba, incloses the Mexican Gulf; the other, curving in an extended semicircle, is the country of the States of the Central Confederation.

"Central America," says Squier, "in respect of geographical position almost realizes the ancient idea of the center of the world." She joins the two continents and opens her ports on both oceans. Bathed on the one side by the Gulf, on the other by the Pacific, and binding herself on the

* From MSS. of Professor Nourse.

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north by Tehuantepec to the Mexican plateau, and on the south by Darien to the highlands of New Granada, she seems destined to concentrate the world's interests. For, besides her favored geographical position within a few hundred square leagues, she has every climate and natural product. She is not, then, like Suez, nature's waste, incapable of colonization, but inviting it, and offering supplies for sustenance and the construction of public works.*

Within the ten degrees of latitude, 8° to 18° north latitude, from Panama to Tehuantepec, with the exception of a few irregularities, a nearly right line is maintained on the coast from east 35° on the south to west 35° north, between 80° and 95° of west longitude, especially on the Pacific side. This coast may, indeed, be considered as made up of two nearly right lines, intersecting at the Gulf of Fonseca, the first line running northeast and forming the coasts of Costa Rica and Nicaragua, the second inclining somewhat from the first and running west 20° north along Salvador and Guatemala. Indentations are found on the first of these lines; on the second the coast line has an almost monotonous regularity.

The Atlantic coast is more broken. It shows three successive indentations, including between them corresponding projections, which result from the general relief of the country; for close attention here shows that the birth, if we may so say, of these was coeval with those mountain peaks that shoot up from the sharp ridge which marks out the backbone of Central America.

This region differs from Mexico in its elevations. It is not an immense plateau, elevated from 6,000 to 7,000 feet above the sea-level.

The great mountain chain of the Isthmus intersects this section in a direction more or less parallel with its northwest coast, closer to the Pacific than to the Atlantic, to which, however, also its lateral ranges approach. Some of the prominent peaks rise nearly to 14,000 feet, and there are a number of volcanic cones, mostly inactive. Not one of these is in the interior nor contiguous to the Atlantic.

The orology of Nicaragua differs from that of all the rest of the Isthmus in its having two nearly parallel mountain ranges running at a considerable angle from the coast line, and discharging their streams into the great reservoir, Lake Nicaragua.

Branches from the main ridge diverge in so many directions that an incessant alternation of mountain and valley is found. The temperature is thus greatly modified, causing such variety of climate that, in the language of the inhabitants, the distinction of "cold," "hot," or "temperate" is applied to districts bordering close upon each other. It is not uncommon to pass through each of these modifications in a distance of ten leagues.

The Prussian geographer Berghaus, in a memoir published in 1838, divides the mountains of Central America into three systems—the groups of Costa Rica, of Nicaragua and Honduras, and of Guatemala. The first of these is separated from the second by the great transversal valley from sea to sea, within which is Lake Nicaragua; the second is separated from the third by the Leanura de Comaygua, in a direction northeast to southeast, a fact conjectured by Humboldt in 1825, and verified by Don Galindo ten years later. The third group is that of Guatemala, filling the whole western part of Central America and the eastern States of Mexico.

The volcanic character of some of these systems is very marked. In a paper read before the American Association for the Advancement of Science, in 1850, by our former chargé in these countries, Mr. E. G. Squier, he says:

"No equal extent of America, perhaps of the globe, possesses so many active volcanoes or exhibits so many traces of volcanic action as the region between Panama and Tehuantepec. They are all on the Pacific coast. The eastern slope, consisting of broken mountain ranges, exhibits few traces of volcanic action. Only ten or twelve give signs of life, although the plain itself is traversed by a succession of cones, from the gigantic Momotombi to the memorable Coseguiria. In natural connection, earthquakes have not been infrequent. They occur more violently at the change of the tropical seasons, the 'wet' and the 'dry.'"

Mr. Squier gave his opinion at the close of his paper that the general effect of volcanoes had

* For details in proof, see Squier's Central America; Trautwine's, Childs', and Michler's Reports, and Shufeldt's, Selfridge's, and Lull's Reports of recent Government surveys. See also a pamphlet published in 1874 by Hon. Mr. Benard, minister resident for Nicaragua.

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been much overrated; that their permanent influence was comparatively local; and that on their line throughout Nicaragua volcanic force had probably exhausted itself. From the general features of the country, it is evident that no material change has taken place in the lakes or their plain for centuries. "The objection raised against a ship-canal from this source was entitled to no serious consideration."

As regards the *rivers* of this region, it may not be amiss to be reminded—

1st. That the narrowness of the Isthmus forbids, in most sections, the existence of a transverse stream of much length.

2d. That all tropical streams present the greatest differences in volume according to the season. Those which in the month, say, of February may be crossed without water to the knees of a horse are massive floods in September. From the earliest days of the adventurous buccaneers, the explorer has fled for his life by a change in the river's volume as rapid as unexpected.

The word "river," therefore, has in many cases no fixed idea here, as it has in extra-tropical zones. Mere ravines, quebradas in the dry season, are apparent "rivers" in the wet. For a line of 1,400 miles the number of permanent streams is small.

AREA AND POPULATION OF THE AMERICAN ISTHMUS—TEHUANTEPEC TO THE ATRATO.

The figures for area and population in regard to the countries making up this Isthmus must be given only as estimates. From their unsettled political state and other causes, no reliable surveys have been reported of such character as those in the other countries of North America. And as regards the taking of a census in any one of these districts, it has been so far found to be wholly impracticable, a large part of the population being Indians, and a large portion of the mixed races and whites being known to flee always from their homes at the merest idea of a census-taking, through fear of its being the basis of taxation or of a military conscription. The following estimates are made to date of 1874:

	Area.	Population.
	Square miles.	
Isthmus of Tehuantepec	16,000	50,000
Central America:		
Honduras	50,000	400,000
British Belize	13,500	24,000
Costa Rica	22,000	167,000
Guatemala	40,000	1,180,000
Nicaragua	58,000	400,000
San Salvador	10,000	600,000
	193,500	2,771,000
Panama*	29,756	175,000
Total estimated	239,256	2,996,000

* Including Chiriqui, Veraguas, &c.

RECAPITULATION OF CHARACTERISTICS OF THE GREAT ISTHMUS.

I. The contour of the section from Tehuantepec to the Atrato presents an extent of 1,230 miles, with a narrowness so extreme as to force, at first sight, the belief that an easy crossing must be practicable for commerce. The breadth reduces itself to 40 and even 30 miles between the waters. The seeming intention of nature has been so to connect the two Americas that the energy and enterprise of man shall remove the barriers between the mighty waters.

II. The geographical position of this section is such as to secure every variety in the products of the warm zone, while its elevated though broken mountain ranges add the climates and products of each of the other zones. Its geographical position, further, has in it everything desirable for securing a commanding commercial position and rule. It is as true to-day as when written by Pater-

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son, nearly two centuries ago, that "this door of the seas, and key of the universe, with anything of a reasonable management, will enable its proprietors to give laws to both oceans and become arbitrators of the commercial world."

III. The physical character of this section in regard to the arrangement of its mountain ranges is as marked as it is in regard to their volcanic cones or in regard to its earthquakes, and still more remarkable as regards the indentation of its coasts and the character of their harbors on each side of lines where the intervening elevation is more or less favorable for interoceanic communication—

In illustration of this peculiar orography in itself, and in its relation to the coast indentations and harbors, let it be considered—

(1) That the Isthmus of Tehuantepec offers a comparative plain or table land of moderate elevation, the highest on a feasible line being but 754 feet—Tarifa. But, to say nothing of the openness of this very depression in the hills to the violent north winds, often for many days, there is no satisfactory evidence of finding or of establishing approaches to or safety in secure harbors inviting commerce.

(2) That in the section next to be considered southward, where the greatest depression and most favorable water supply exist—Nicaragua—the coast lines present inferior harbors.

(3) The direction of the mountain ranges continues throughout nearly the whole of the Isthmus to be in a line parallel with the coast line, changing, however, in the southern section from a nearness to the Pacific shore, as in Nicaragua and San Salvador, to a nearness to the Atlantic throughout Darien. A glance at the physical map of the last-named section, bringing before the eye such river courses as those of the Bayano, the Savana, Tuyra, and Chucunaqua, seems to force upon every one, by their volume and by their extent westwardly across this narrow 30-mile intervene, that a pass must be discoverable. But the Cordillera arrests the surveyor's hopes almost at the outset of his journey from the lower courses of these streams.

The general impression, therefore, upon which one is forced back, in regard to the whole Isthmus, is this, that a great depression in the Cordillera on this narrow neck has a corresponding delta and shoal shore in place of harbor on the coast; and that where depth of anchorage within shelter is found, it is a depth born, as one might say, out of the upheavings of the Cordillera which intervenes to frown on man's mightiest efforts for free crossing between the seas.

Yet the geographical position of the Isthmus in its relation to inter-oceanic communication is so marked that the world has unceasingly demanded the fullest explorations of the regions in question, especially that of Darien, known for so long a time under the Spanish designation "El Istmo," and practically hidden from anything like even exploration until the middle of the present century.

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CHAPTER VI.

DARIEN AND THE VALLEY OF THE ATRATO—PHYSICAL FEATURES, PECULIAR OROGRAPHY, ANIMAL LIFE, INHABITANTS.

THE ISTHMUS OF DARIEN AND THE VALLEY OF THE ATRATO.

Darien, geographically considered, is a province of the State of Panama. Its Atlantic coast line is included between Point San Blas and Cape Tiburon; that of the Pacific from the mouth of the Bayano to Point Ardita. The eastern boundary is determined by the main Cordillera in its sweep across the Isthmus from a position of close proximity to the Pacific, near Point Ardita, to a similar position near Tiburon, on the Atlantic. The valleys of the Mandinga and Mamoni-Bayano determine its western limit.

In the province of Choco, State of Cauca, immediately adjoining Darien, lies the valley of the Atrato. Its proximity to Darien, and sharing with that province some part of several lines of exploration, has caused it to be referred to as on the Isthmus of Darien, but, geographically considered, both physically and politically, it is not, as the Isthmus terminates at the Gulf of Darien, and the valley of the Atrato exists as a part of the South American continent.

A glance at the map will convey a clearer idea of the configuration of the coast lines of Darien than a description would, and will serve to show the highly attractive feature which this district possesses in its excellent harbors; a feature which it almost monopolizes, as there is no other portion of the American Isthmus so well provided for in this respect, and its wealth of terminal points makes the poverty of favorable internal features still more aggravating.

Continuing a study of the maps to gain a knowledge of the principal topographical features, it will be seen that the country is essentially one of rivers, and while they appear in great numbers, there are but few which have great length, the principal of these being the Atrato, Chucunaqua, and Tuyra.

The presence of so many watercourses—and if all that exist were accurately represented on a map of large scale, a complicated network would appear—will suggest extraordinary conditions of climate and marked orological features. From the narrowness of all valleys, and from the short distance between headwaters, it can be inferred that the ridges which lie between them, if they have height, must be very steep. That they have height can be inferred from the evidences of excessive rains in the multitude of streams, and that this immense rainfall, acting for ages, certainly caused deep erosion. Falling upon steep escarpments, heavy rains would find the most favorable conditions for carrying on the leveling process, and these ridges would not appear if they had not been protected in some manner. This protection is furnished by a dense forest, which not only breaks the fall of the rain, but through the infinite interlacings of the roots of its trees and undergrowth the surface soil is held quite firmly in place, and is thus enabled to resist in a measure the erosive action of falling water.

The energy displayed by these heavy rains in carrying on the work of denudation would, if acting uninterruptedly, prevent the formation of the forest, which now tends to diminish their power, and therefore it must have found in an abatement of such an active opposition the means of development. The existence of these two antagonistic forces, although each in a measure favors the other, will be found to depend upon the same cause—the movements of the Atlantic trade winds.

In the equatorial region, where the northeast and southeast trades approach each other, there is a conflict of winds, resulting in a belt of calms. The air of this belt having its temperature raised, and being pressed on each side by the whole force of the opposing trade winds, is forced to ascend. The trades pour their moisture-laden air into this current, which, as it ascends, expands

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and becomes cooler; condensation then takes place and precipitation follows. This action being constant, we find this region to be one of incessant rains.

The trade winds, depending upon the sun, are influenced by its movements in declination, so that the whole trade-wind system travels a certain distance north and back again south every year. The zone of calms, which in itself varies from 5° to 7° in width, thus travels through 17° of latitude, coming as far north in summer as 12° or higher, and in the winter receding to 5° south of the equator. All places within this arc come under its influence at certain periods of the year, and, as a result, we have the well-marked rainy seasons of these latitudes. It can be readily seen that localities near its northern and southern limit feel its effects for a single period each year, while those occupying a more central position on the arc come under its influence as it passes them going north and again when returning south, thus causing two rainy and two dry seasons each year.

Darien comes within this bi-rainy zone, and has for its driest months January, February, March, part of July, August, and part of September, the rainy seasons occurring in April, May, June, part of September, October, and November, there being, generally speaking, five dry and seven wet months each year. The dry seasons are not, however, entirely free from rain, but, when compared to the excessive wetness of the other seasons, they well deserve the title. The dry months are rendered very pleasant by the trade winds which prevail, and vegetation advances with wonderful strides under their favoring influence, but during the rainy season there is little or no wind, and, as a consequence, the warm, humid atmosphere is stifling. This disagreeable condition is rendered still worse when, during intervals between showers, the sun appears, and with all its tropical power converts the moisture of the air into a vapor, which may be seen sluggishly rising from all exposed surfaces.

Keeping in mind these climatic conditions, imagine that the barrier between the two oceans, when first upheaved, consisted of an immense mound of clay, with a moderately broad, undulating surface. The rains would fill up all the depressions, and the result would be an immense number of lakes, ponds, and pools; these overflowing, the work of abrasion commences, and is carried on with an energy depending upon the fall and supply of water. The most elevated and deepest lakes possess these advantages in the greatest degree, and consequently the erosive power of their waters, exerted with more energy and during a longer interval, results in the deepest abrasion, which becomes the bed of the largest river in that basin. Meanwhile, the waters of a neighboring lake, in seeking their way to the same ocean, have determined the bed of another river, which may follow a course generally parallel to that of the first. Between them there will be a mound or divide, which, acted upon in the same way, will have its slopes scored out in shedding its waters into the rivers at its base. The tributaries thus determined have in turn their mound or divide, which, obeying the same influences, has its slopes scored out in pouring its waters into the tributaries, and so on almost indefinitely; the system of waterways thus produced resembling in plan the arrangement of veins in a leaf, the principal vein representing the main river or deepest depression; its branches the tributaries, and so on.

As long as the supposed clay mound remained unprotected, the constantly increasing power of the waters from increased slopes, while scoring out a deeper bed, would wash away the bases of adjoining slopes, and eventually, in the descent of their beds to the ocean level, the whole barrier would disappear. But at the end of the first rainy season, relieved from the constant washing down, vegetation would advance slowly at first, and on the return of the rains resist in a measure their denuding effect, but it would not be until many dry seasons had intervened that the roots would be sufficiently strong and matted together to retain the inclosed soil. Its early development would be most rapid where it was least disturbed. A line of least disturbance would be determined by following along the mound or divide the points of greatest altitude, and from this center line of strength vegetation would work downward on the now rapidly increasing slopes and eventually cover them. The mound thus acted upon, protected at the top and undermined at the bottom, while retaining generally its altitude, loses greatly in bulk, and becomes a well-defined sharp ridge.

Instead of a clay mound, one of rock has been subjected to these forces, and in this case, while the work of erosion was much slower, it was largely aided by the decomposition of the surface rock, due to excessive heat and moisture. The ultimate result has been the formation of these sharp ridges as a prevailing feature, and this is true not only of the main divide itself, but of all the

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ridges which exist between rivers, their tributaries, the streams which flow into these, and down to the little ridge which divides two small brooks. The crests of these ridges are generally only a few feet wide, occasionaly broadening out considerably, but even the highest of them may be followed for long distances on a crest so narrow as to be easily straddled.

Taking up again the leaf used to illustrate the plexus of watercourses, a correct idea of the peculiar orology of Darien will be found by considering its parts included between the veins as raised into such ridges as have been described. The mountain system thus presented will represent the main Cordillera, or divide, its huge branches, the ridges which shoot out from these, and the spurs from the latter, which in turn branch off into minor spurs.

A knowledge of this thoroughly connected system would have saved the reputations of many explorers, but, unfortunately for them, it was only acquired during recent explorations undertaken by the United States. This discovery resulted in much good, not only in adding to the certainty of results obtained by a comprehensive system of reconnaissances, but in saving the heavily taxed strength of the explorer making them. A trail along the crests of these ridges would ascend and descend by comparatively easy slopes, but if a bee-line were followed the greatest exertion would be required in climbing and descending the steep slopes of a succession of these ridges, and in the end the horizontal distance gained would not be much if any more than half of that actually walked. The profile of such a path, represented by the serrated edge of a saw, will make this manifest. This rugged feature exists throughout Darien to the exclusion of undulating surfaces, and the only level lands encountered are those formed between the bases of projecting spurs by deposits of gravel, clay, and alluviums. Overlying the rock formation is a stratum of firm, yellowish-red clay, varying in thickness from a few feet on the crests of ridges to twenty feet at their bases. This, when wet, necessitates additional exertion in traveling over the steep slopes, as its surface becomes very slippery and its unyielding nature refuses a good foothold.

Having had a glimpse of the surface, as it would appear if exposed, it will now be regarded with its mantle of an almost impenetrable forest, extending from the bottom of the deepest ravine to the crest of the highest ridge, and so dense that within it the view is limited to a radius of a few feet. Its grandeur offers a splendid field for writers possessing the poetic element, and many descriptions in this vein have been rendered so elaborately as to convey the idea that it is a fairy land instead of the reverse. The energy with which nature works, and the resulting forms and combinations, framed in by such solitude, are sure to attract attention from even an exhausted explorer, but it is seldom he can relapse into the reflective mood, as the many distracting annoyances comprehended in weary legs, a perspiring and insect-tormented body, are prone to develop the weak rather than the poetic side of his nature, and it is always when far away from the scene of his travels that the pent-up emotions are released. For the present purpose a matter-of-fact description will be better, and, if competently given, it would have the special advantage of permitting free play for individual reflections.

Standing within this forest, the elements which first attract attention, and which from their oppressive nature seem to outweigh any charms it may possess, are its deep gloom, the motionless air, its damp, musty, wood-decaying smells, the thick carpet of vegetable mold, moist and black, suggesting slimy inhabitants, its tormenting insects, the profound silence, made manifest by the least movement, and, above all, its intense solitude. From the feet upward and in every direction is a dense mass of vegetation, a green canopy which completely shuts out a view of the heavens, tempers the bright sunlight which falls upon it with its own greenness, and prevents the refreshing wind which blows over it from agitating the prison-like air within. Noticing the surrounding forms, the graceful family of palms, in its endless varieties, is conspicuous, and furnishes, with the myriads of parasites, which seek existence from living and even prostrate trees, the chief distinctive elements of the scene. Trees of every conceivable diameter, from the giant of twelve feet or more to the stripling of a few inches, tower upward, and the latter, in its eagerness to reach the realms of sunlight, attains a height out of all proportion to its girth. Generally devoid of branches except at the top, many of these trees resemble stately columns, and one, the bungo or cotton-wood, giant of the forest, is strikingly attractive in this respect. Covered with an even, granite-colored bark, its trunk widens into quite a bulge near the ground, and, returning quickly to its original diameter, thence tapers gradually as it proceeds upwards for over one hundred feet. In

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marked contrast to this simple form, there occurs a large tree which appears as though made up of vines, so ribbed is its surface, and from its manner of growing develops architectural features which would entitle it to be called the cathedral tree. Proceeding from the ground like so many individual trees are a large number of trunks, which, by curving more or less abruptly, converge to a point overhead, from which springs the main body of the tree. It is thus supported by a number of arches, through some of which a wagon-load of hay could pass easily, and in form many of them are quite perfect, while the architectural effect is heightened by the fanciful traceries resulting from the appearance of the deeply ribbed surfaces. Looking in another direction, trees of various sizes appear supported at their bases by board-like roots or buttresses which in the largest trees may extend from twenty feet above the base to a greater distance from it on the ground, thus forming around them large triangular stalls.

The very noticeable feature of a general absence of branches, except near the tree-tops, is more than made up for in the immense number of vines, varying in size from that of a piece of cord to the mammoth of many inches in diameter, which display themselves in every direction. They travel everywhere and in every conceivable way; they run along the ground, climb straight up the side of a tree, or twist around it, and sometimes with sufficient force to imbed themselves. Reaching the branches, they work out and drop down in loops of a hundred feet or more; they struggle with and entwine each other until a large cable is formed; they work unceasingly, and, aided by numerous other parasites, destroy the victim to which they cling.

To move forward from this post of observation, a way must be cut through the jungle. Progress is slow and the ordinary exertion of walking causes profuse perspiration; attention is continually called to the safeguards against parasites and animals with which certain plants and trees are provided, and is generally attracted by the pain which these nettles, spines, and thorns cause when unconsciously run against; a dense mass of cactus, growing eight or ten feet high, in clumps of grass-like blades, with strong, sharp thorns along their edges, is now encountered, and the difficulty of cutting through it may be increased occasionally by disturbing a wasp's nest; passing this, the path may come upon a mass of matted vines so high and so thick as to defy cutting. All this while it has been necessary to climb over or crawl under, according to position and size, the many prostrate trees, and in doing this it is observed that a puncture like that of a red-hot needle is the common form of introduction to different varieties of insect life. The path now follows one of the spurs, and the exertion of climbing up its steep slope tells heavily; the warm, humid, motionless air seems of no use to the gasping mortal; bathed in perspiration, with a heart pulsating like a trip-hammer, with weak knees and lead-like feet, the top is reached. Then, as in the ravine below, all vision is limited to the few surrounding trees, and although the crest may be so narrow that a single tree occupies its whole width, no vista can be obtained. Continuing on, the descent is begun, and now the body is subjected to a jarring, racking process which seems to be all that is needed to utterly demolish the almost used-up human machinery. Emerging from the forest seems like coming from a dungeon of torture, and the by no means bright light of the closed-in river seems dazzling.

Of the species of animal life which here abound, the higher forms, contrary to what would generally be expected, are few as regards varieties, and comparatively so as regards numbers. The gloomy surroundings of the forest, aided by preconceived ideas of the number and ferocity of its wild animals, would naturally tend to some uneasiness, but if all the other forms of life interfered with the explorer as little as these higher forms, existence then would be rendered much more endurable. The jaguar, or tiger of the natives, while frequently seen, has rarely been known to act on the offensive. Monkeys and peccaries rank first in point of numbers, and upon them the hunter depends largely for his meat supply. The tapir also adds to this store, but not to any extent, as it is rarely encountered. Of the feathered tribes, the family of parrots is the most numerous. A few wild turkeys, partridges, and ducks are to be seen, but all game is quite secure in the high tree-tops, and if brought down by a lucky shot, the difficulty of recovering it from the jungle still remains. Reptile life, as would naturally be supposed, is very abundant, and many of the snakes are venomous.

All the indifference to man's presence on the part of the higher forms of life is more than compensated for by the unremitting attention of the insects. Abounding in marvelous numbers and

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surprising variety, from the microscopic yavis, which penetrates the skin and produces troublesome itching, to the giant tarantula, there seem to be a complete assortment of varieties, each of which pursues some specialty in the art of torture, and has its own time and field for operations. The result of this incessant attack, night and day, moving or resting, may fittingly be called agony.

INHABITANTS.

With such an environment it seems strange that any branch of the human family could successfully contend, yet such is the case, and even Darien has its sons who love their native land, and can even boast of heroes who have successfully defended it.

Our historical knowledge of the Darien Indians is very limited, and of their language and customs comparatively little is known. Having a traditional distrust of the white man, particularly of the Spaniard, they maintain a policy of non-intercourse, and, whenever it is within their power, exclude all strangers from their territory. When this is impossible, owing to inferiority in numbers or weapons, they desert their villages and retire to localities where they and their families are beyond the reach of the intruders. This practice of hiding away the women and children is invariably followed, even if they have assurance that no conquest is contemplated. Their traditions, in recounting the deceptions and cruelties practiced by the conquerors of the New World upon the tribes which came under their power, teach them to place a low value upon the character of the white race, and in this view they are certainly justified when the barbarities of the Conquistadores are recalled. Referring to these excesses, Irving says: "Our admiration of the dauntless heroism displayed by the early Spanish navigators, in their extraordinary career, is much qualified by a consideration of the cruelties with which it was tarnished, too great to be either palliated or passed over in silence by the historian. As long as Isabella lived, the Indians found an efficient friend and protector; but 'her death,' says the venerable Las Casas, 'was the signal for their destruction.' Immediately on that event, the system of *repartimientos*, originally authorized, as we have seen, by Columbus, who seems to have no doubt, from the first, of the Crown's absolute right of property over the natives, was carried to its full extent in the colonies. Every Spaniard, however humble, had his proportion of slaves; and men, many of them not only incapable of estimating the awful responsibility of the situation, but without the least touch of humanity in their natures, were individually intrusted with the unlimited disposal of the lives and destinies of their fellow-creatures. They abused this trust in the grossest manner, tasking the unfortunate Indian far beyond his strength, inflicting the most refined punishments upon the indolent, and hunting down those who resisted or escaped, like so many beasts of chase, with ferocious bloodhounds. Every step of the white man's progress in the New World may be said to have been on the corpse of a native. Faith is staggered by the recital of the number of victims immolated in these fair regions within a very few years after the discovery, and the heart sickens at the loathsome details of barbarities recorded by one who, if his sympathies have led him sometimes to overcolor, can never be suspected of willfully misstating facts of which he was an eye-witness."*

Possessing traditions filled with the details of these barbarities, it is no wonder that the Isthmus tribes should regard with a jealous eye the movements of all foreigners, and that they should have assumed such a warlike character as to draw forth and merit the Spanish title of "Bravos." It is not likely that they were naturally warlike, but with such a serious fate before them if they yielded to the adventurers in any degree, it is easy to understand their determined resistance, and it is safe to presume that, with all their bravery, they too would have fallen under the conquering arm had it not been for the protection afforded them by the rugged nature of their country.

The Darien, or, as they are frequently called, San Blas, Indians inhabit all of the Isthmus of Darien as far eastward as the mouth of the Atrato, excepting the lower portion of the Bayano and Tuyra Rivers. While designated under this general title, there does not seem to be any evidence of a single tribal organization, but rather a number of tribes, with the same habits and

* This reference is to Las Casas, who affirms that more than 12,000,000 lives were wantonly destroyed in the New World within thirty-eight years after the discovery, and this in addition to those exterminated in the conquest of the country.

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customs, living independently of and peaceably with each other. They each have their head-man, or chief, to whom all pay great deference. The majority of these tribes are located on the Pacific slope, on the tributaries to the Bayano, Chucunaqua, and Tuyra, and receive their distinctive name from the valley they inhabit. Thus we have the Chepos, Mortis, Navigandis, Chucunas or Chucunaquas, Sucubtis, and Payas. These, with the Tanelas on the Atlantic slope, are the tribes which have received the title of "Bravos," but it is particularly applicable to the tribes in the Valley of the Chucunaqua.

The coast Indians, being more exposed to the advances of foreigners, have come well under their influence, and for this reason they are distrusted by the mountain tribes, of whom they stand greatly in fear. While willing to give any information in their power regarding the interior, and to act as guides, they will refuse to enter the territory of their powerful neighbors with a stranger. They are particularly fond of the English-speaking race and adopt English names. This discrimination, also made by the Bravos, but not to the same extent, is due to the respect engendered for the Buccaneers in their successful raids upon the life and property of their common enemy, the Spaniard.

Any statement as to their number depends solely upon guesswork, but it is probable that there are not less than seven thousand. They possess the general characteristics of the Indian race, and, while otherwise well developed, they are undersized, rarely exceeding five and a half feet in height. They are strong, however, and in their movements exhibit activity and grace While able to endure great physical exertion, if necessary, they generally yield to a mental weariness which unfits them for a continued effort.

Their arms, originally the bow and arrow, have been largely supplemented by the ordinary shot-gun of a very poor quality. These and other articles, such as cotton cloth, beads, iron pots, &c., they receive through traders who visit the coast, in exchange for ivory nuts and rubber.

Their wardrobe is generally limited to a clout for the men, and a piece of cotton cloth, falling from the hips to the knees, for the women. In displaying gold and silver ornaments from the nose and ears they exhibit the usual fondness of the savage, and also add to the adornment necklaces made up of beads and teeth of animals. They seldom tattoo, but frequently smear their bodies with a black fluid. This blacking process is not carried on so as to cover the whole body, but generally extends from a well-defined line at the height of the nipples down to below the knees. The effect produced is that of a snugly fitting, seamless undergarment.

Of their forms of religious belief nothing is known more than that they recognize a Supreme Being and believe in evil spirits, over whom their pawawas, or medicine-men, claim to have control. Whatever their belief may be, they seem to have a good code of morals, as evinced by their modesty and honesty. They are certainly treacherous to the foreigner, but in this they are justified by the well-grounded fear they have of him.

The Indians of the Atrato Valley were evidently less fortunate than their Darien neighbors in escaping the Spaniards, as would be inferred from the scattered remnants of the Cholos now existing without any semblance to a tribal organization. The immense mineral wealth of the Atrato Valley could not escape the adventurous Spaniard, and it is likely that the Cholos, brought to subjection, added largely in swelling the total of lives crushed out by their greedy taskmasters. In their reluctance, at this day, to search for gold or to give any information respecting it, they exhibit the fear that the barbarities inflicted upon their ancestors might be repeated upon them.

Regarding their origin, Lieutenant Collins, U. S. N., says: "It is somewhat uncertain which of the great semi-civilized nations of America these people have descended from. They are thought by some to possess many characteristics indicating a relationship with the Aztecs or Toltecs. Their nearest neighbors must have been the powerful Chibchas or Muiscas, and if the boundaries of the territory of that nation are correctly given by Acosta, it must have included the headwaters of the Atrato; and if it be true that the name 'Chibcha' was given by the Spaniards on account of the frequent repetition of the syllables 'chi' and 'cha,' the continued recurrence of the same syllables in the language of the Cholos would appear to indicate, if not establish, a claim to relationship in that direction. But there is nothing in the appearance or condition of the Indians of the present day to indicate a descent from powerful and cultivated ancestors, however remote."

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The possible relationship indicated receives additional support from Dr. Seeman,* who states that the wide range of country over which the Cholos are diffused (from 2° north to 8° 30′ north) "explains an historical puzzle." * * * "When reading of the discovery of Peru, how the Spaniards gradually pushed southwards along the shores of America, everywhere inquiring after the empire of the Incas, and even obtaining information of the city of Cuzco, we are at a loss to explain how the discoverers could understand the stories related to them, how the parties could make themselves intelligible. Even the best historians have not explained this puzzle. But the fact that the same language is spoken from San Miguel to the northern boundaries of Ecuador, where the Ouichua commences, and that it was familiar to the Spaniards before starting on their expedition, renders the proceeding intelligible."

Of this once numerous tribe there remain but few representatives, and these are found scattered over a large extent of country, each family living by itself. They bear evidence of being a completely subdued race, and in yielding to the negroes as superiors show how complete this submission is. In disposition they are timid, and not given to quarreling, except when under the influence of liquor, and even then do not go to excesses. They are kind, hospitable, and faithful. Their honesty is quite phenomenal. The property of a stranger needs no safeguards, and might remain exposed for an indefinite period and not a single article would suffer displacement.

Of their religious belief hardly anything is known. "They are so averse to communicate on the subject of religion," says Lieutenant Collins, "that I found it impossible to draw from them directly anything relating to it. I learned, however, the following particulars from a very intelligent young negro, who had been much among them and was acquainted with their language. If his account of their daily anticipation of the arrival of a god to set up a kingdom on earth is correct, the fact is certainly a most curious one. According to his account, the Indians worship a god whom they call Jay (pronounced *ha-ee*), and whom they represent by a rude figure of an animal. I have seen them wearing these in their hair, but was unable to make out what animal they were intended to represent. Their priests they call Jaybanas. They have no stated season for holding religious services, but generally hold them on the serious illness of any one, or such special occasions. These services are always held after nightfall and without lights. The jaybana recites in a monotonous chant certain legends, and the people listen in silence. Women are admitted to the priesthood, and young boys and girls are kept in training, learning the legends. They expect daily a god inferior in power and dignity to the great Jay, who is coming to establish a kingdom on earth."

A large portion of the Isthmian population is made up of negroes, descendants from African slaves employed by Spain in her colonies as early as 1501. This slavery existed in New Granada until the year of independence, 1821, from which date a gradual emancipation took place, and in 1850 the Government redeemed all slaves not yet free.

The negroes of the Isthmus are to be found chiefly along the banks of the Atrato, near the mouths of its tributaries, and along the banks of the rivers which enter the Gulf of San Miguel. They are tall, well-formed, and very strong, the muscular development in many cases being marvelous. They can carry very heavy loads on their backs for long distances over rugged mountain trails, and, when necessary, can accompilsh a great deal in the way of endurance, but soon weary of continued work, even of a light character. They make good woodsmen and fair hunters. In the handling of their canoes they are very expert, and from the use of the long pole, which is needed to guide and propel the canoe through the shoals and rapids of a river, they acquire a movement of body which is characterized by ease and grace. In dress they conform generally to the Indian fashion, but frequently appear clad in one or more garments which are general in more civilized communities, and it is only then that they seem to be undressed. For subsistence fish and plantains form the staples, to which they add rice when well enough off to buy it. To procure money for such luxuries as rice, salt, cotton cloth, guns, ammunition, and rum, journeys are made to the mountains, where rubber is collected. When a sufficient supply has been secured, they return to the hamlet and have its storekeeper, banker, &c., generally a white man, place its value to their credit. In

* Voyage of H. M. S. Herald, Dr. Seeman.

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doing this the patron, as he is called, takes care to keep them on the debtor side of his ledger, and thus retain his power over them. This system keeps them always in debt and makes them virtually his slaves, and while calling themselves his peones, or laborers, they regard highly their title of Libres.

Their moral character is generally good, and they, in common with the Indians, enjoy a reputation for honesty. This has often been proven, and, as an instance, it can be stated that a Government officer in paying certain canoe-men during one of the United States expeditions was advised by one of them that a mistake had been made in his account. The disbursing officer was quite provoked and declared that it was impossible, but the peon persisted that one had been made, and went into particulars, explaining the circumstances under which he asked for and received two dollars during the early part of the expedition, and that the disbursing officer had evidently failed to charge them against him. This same officer, with the funds of the expedition in his camp-chest, mostly silver, traveled for several weeks through the country with no other companions than his two canoe-men, and they not only knew that the chest contained money, but from its weight had an exaggerated idea of the amount. When stopping for the night at a hut, the advent of the stranger would attract quite a crowd of native visitors, and when in their presence one of the canoe-men landed the heavy chest on the floor and called attention to its being filled with money, there was an universal exclamation of surprise. Far from feeling any uneasiness, the officer enjoyed a sense of perfect security, not only as regarded himself and money, but, down to the most insignificant of his personal effects; he knew that they were safer there than if surrounded by civilization and the best system of burglar alarm and police telegraph.

The Spanish is, of course, the language of the country, and all its polite forms of expression are constantly in use by all classes in their intercourse with superiors and with each other. A request made is gracefully fulfilled with a "Con mucho gusto, señor" ("With much pleasure, sir"), and "Si, señor" and "No, señor" take the place of a rude "Yes" or "No." It is true they are not pressed for time, and are thus freed from the necessity of resorting to briefer forms suited to the pace of busy throngs.

Of time they take no more notice than that days come and go; as to its other intervals their ideas are very crude, and the same estimate may be placed upon their conception of distances. Any information given by them regarding these elements of a journey is invariably wrong, and better results would be obtained by taking the average of a number of wild estimates made by one's self.

The proverbial slowness of the Spanish American attains its fullest development in this region, and, in consequence, an explorer with limited time and much to perform is doomed to many vexations. This characteristic is humorously described and philosophically considered by Trautewine in his "Rough Notes of an Exploration in the Atrato and San Juan Valleys." He says: "I had supposed, like a simpleton, that in order to start on my pilgrimage nothing more would be necessary than to go down to the landing, engage a canoe and two or three paddlers, tell them to put my traps and a few plantains on board, and be off at ten minutes' notice. Consequently, early one morning, following the example of my thermometer, I rose with the sun, went to the landing, and, accosting the owner of a canoe, bade him gird up his loins and bring his boat around to our landing place in order to load up with more facility. He very courteously asked me for a light, and, after having gravely set his cigar in operation, told me he could not comply. The voyage was a long one, and required a good deal of deliberation and consultation among his kinsfolk; provisions were very high just then; himself and his family were victims to all sorts of distressing maladies; his canoe leaked and would require repairs; it was going to rain (a truism at all times in Quibdó); and, besides, to-morrow or next day would be time enough.

"The inexperienced traveler on the Spanish Main is very apt to be continually annoyed by the dilatory habits and procrastinations of all with whom he has business to transact. This should not (as is usually the case) be imputed to them as a fault, but rather as a natural consequence, resulting from the heat of the climate and the absence of those incentives to activity engendered by a more extended commerce or a general devotion to agricultural pursuits. The traveler from colder regions should therefore make ample allowances for these considerations, and temper his impatience down to the standard of inactivity which prevails in all tropical climates. Otherwise,

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he will be kept in an incessant fidget and ill-humor; for no matter how pressing may be the occasion, how solemn the promises, how urgent his importunities, he is constantly met with the eternal 'Poco á poco,' 'Mañana' ('By and bye,' 'To-morrow'). 'Take it coolly'; 'Don't hurry yourself'; 'Don't do to-day what can be done to-morrow'; 'Time comes as fast as it goes,' constitute the grand fundamental axioms of business operations from the most important down to the most trifling incidents of every day's occurrence. Do you complain? You are consoled by the assurance that it is the 'costumbre del pais' (the custom of the country). And so it is; therefore, the sooner you learn to conform to it, the sooner will you be relieved from a most prolific source of irritation."

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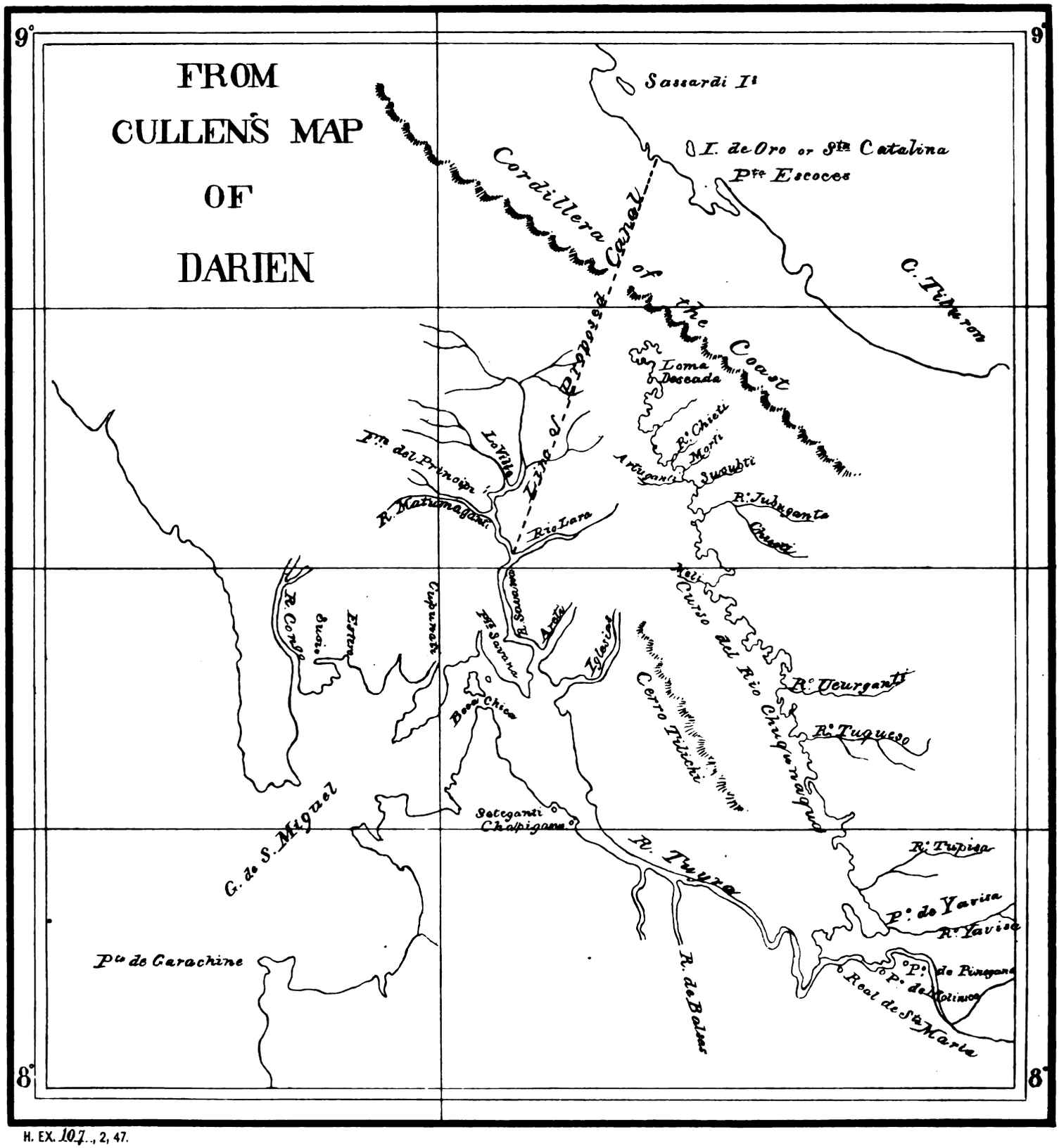

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CHAPTER VII.

CALEDONIA ROUTE—CULLEN'S PROJECT AND THE RESULTING EXPEDITION—STRAIN'S EXPEDITION AND THE OPERATIONS OF ENGLISH AND FRENCH PARTIES IN THE VICINITY OF CALEDONIA BAY—THE SEARCH FOR STRAIN—STRAIN'S JOURNEY—BOURDIOL'S SURVEY.

CULLEN'S PROJECT AND THE RESULTING EXPEDITION.

In 1850 the project of a ship-canal across the Isthmus of Darien, between Caledonia Bay and the Gulf of San Miguel, was placed before the world by Edward Cullen, M. D., F. R. G. S., of Dublin, in communications to the press, in a paper to the Royal Geographical Society, read at the Edinburgh meeting of the British Association in July, 1850, and in a report to Lord Palmerston, January 15, 1851. Subsequently, in December, 1851, his views were laid before Messrs. Fox, Henderson, and Brassey, of London, who were led to believe from his statements that the route designated was favorable to the location of an interoceanic ship-way, and with a view to its development they engaged the services of Mr. Lionel Gisborne, C. E., and directed him "to ascertain the practicability of interoceanic navigation for the largest ships at all times of tide." He left England for this purpose in April, 1852, and returned the following July. His report, which was highly favorable, will be referred to further on.

While Gisborne was on his way to make an examination of the route, Dr. Cullen was in Bogota, and, in the names of Fox, Henderson, Brassey, and himself, obtained a concession from the Colombian Government, granting them the exclusive privilege of cutting a ship-canal across the Isthmus of Darien, between Caledonia Bay and the Gulf of San Miguel. Subsequently, Cullen prepared a work entitled "Isthmus of Darien Ship-Canal" in which much space was devoted to matters of general interest relative to Darien and the ship-canal project, but upon the important subject of the route itself very little was said. With the exception of a description of the terminal harbors, the following quotations contain all that he offers regarding the characteristics of the proposed route, and it will readily be inferred that, if the country were such as he described it, there could have been but little difficulty in securing such data as would have supported his general assertions.

"DISCOVERY OF THE SAVANA RIVER AND THE ROUTE FOR THE SHIP-CANAL.—I imagine that the river Savana was not delineated in the maps which Humboldt saw. Such, indeed, was the case with the map which I had on my first journey into Darien, in 1849, so that I was totally ignorant of its existence until I actually saw it, after entering Boca Chica, when, finding the great depth of water at its mouth, and that it flowed almost directly from the north, I became convinced that I had at last found the object of my search, viz, a feasible route to the Atlantic, and thereupon immediately ascended it, and crossed from Cañasas to the sea-shore at Port Escoscés and back, and subsequently, in 1850, and also in 1851, crossed and recrossed, at several times and by several tracks, the route from the Savana to Port Escoscés and Caledonia Bay, notching the barks of the trees as I went along with a machete or cutlass, always alone and unaided and always in the season of the heaviest rains.

"From the sea-shore [Atlantic] a plain extends for nearly two miles to the base of a ridge of hills which runs parallel to the coast, and whose highest summit is about 350 feet. This ridge is not quite continuous and unbroken, but is divided by transverse valleys through which the Aglaseniqua, Aglatomate, and other rivers have their course, and whose highest elevations do not exceed 150 feet. The base of this ridge is only two miles in width; and from its south side a level plain extends for thirteen miles to a point on the river Savana, called Cañasas, which is about twenty miles above its mouth."

With one or two repetitions of the substance of the above quotations, this is all he had to say, in a work of 200 pages, upon the vital and really only unknown part of the question. It is

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somewhat surprising that this disparity did not receive the attention it deserved as indicating how little Cullen knew about the route he proposed; as it seems reasonable to suppose, from his profuseness upon matters incidental to the subject, that if he had had the means of substantiating his assertions he would certainly produce them at length; failing in that, he boldly launched his statements, clothed in a simplicity that was attractive, and with a directness of statement that was intended to carry conviction.

This absence of data to sustain his assertions was very much regretted by several prominent writers on the question of interoceanic communication, notably Admiral Fitzroy, R. N., but, owing to the zeal and persistence with which he advocated this route, and having no means of refutation, they were inclined to believe the conditions to be as presented by him, but in the light of subsequent developments it will be seen how imperfect was his claim to consideration.

As already stated, Gisborne made a favorable report of the result of his examinations, and, while not exactly in agreement with Cullen, he presents a route that is essentially the same and equally attractive. Quoting from that portion of his report which describes his operations on the Isthmus, we have the following, which certainly characterizes his work as the crudest kind of a reconnaissance:

"At Carthagena we obtained information which fully confirmed what we had been led to expect from the little we gathered in England; that no strangers had been allowed to visit the interior since the Buccaneers assisted the natives in repelling the Spaniards, nearly two hundred years ago; that it was vain to think of obtaining from these jealous savages permission to enter their territory, and that to do so without their permission was hazardous in the extreme. Yet, as it was generally supposed that the summit level between the two oceans was near the Atlantic coast, and it was therefore important to ascertain whether that was a fact, we determined to make the attempt. From the schooner, the Cordilleras appeared to run in an unbroken range. We landed on the morning of the 17th of June, and crossed this range without any obstacle, ascertaining the lowest point visible from the seaboard to be 276 feet high. Beyond this point we followed a small stream, which led us to a larger river flowing from the southwest, in a semicircular sweep toward the north. A flat plain extended to the southwest, in the direction of the Gulf of San Miguel, as far as the eye could reach; looking over the tops of trees from a bluff, about 100 feet high, which we ascended for the purpose, we obtained an uninterrupted view for at least six miles in that direction.

"We followed the course of this river to the north until dark. Early the following morning two Indians in a canoe came in sight, who, upon perceiving us, instantly landed and fled to the woods. Proceding on our journey, we met a few hours afterwards a woman and two children (one an albino), from whom we were unable to derive any information. We had scarcely passed her, when a canoe suddenly appeared with five well-armed Indians in it, who made us understand that we were to follow them, which we thought it prudent to do. They led us fortunately along the course of the river, which gradually assumed a more easterly direction, winding among the hills that overlapped each other, until we reached a village at its mouth, in Caledonia Bay. We were thus singularly assisted in our object by the discovery of a passage through the range of the Cordilleras, which had been heretofore supposed to be unbroken.

"Here an Indian who spoke a little English, and seemed a principal man in his tribe, questioned us as to our object in entering their territory. Thereupon a meeting was held of the chief men, who detained us prisoners. After several hours, and with great difficulty, we prevailed on them to allow us to return to our vessel, on the condition, however, that we should set sail instantly, and upon the understanding that if we were again caught in the interior more summary measures would be adopted. Five or six Indians accompanied us to Port Escoscés, about five miles off (where our vessel was lying), and they remained until the afternoon, when we were well off the coast.

"Our great object had, however, been obtained, in finding that the Cordilleras, which appeared from the sea a continuous range, had an intervening valley, and that the summit between the two oceans must be the center of the Isthmus, if not nearer the Pacific coast."

Leaving Port Escoscés, Gisborne and his assistant, Mr. Forde, proceeded to Aspinwall, crossed over to Panama, and there hired a small schooner to convey them to the Gulf of San Miguel. On June 29 they arrived at Boca Chica, the entrance to Darien Harbor, and on the following day proceeded

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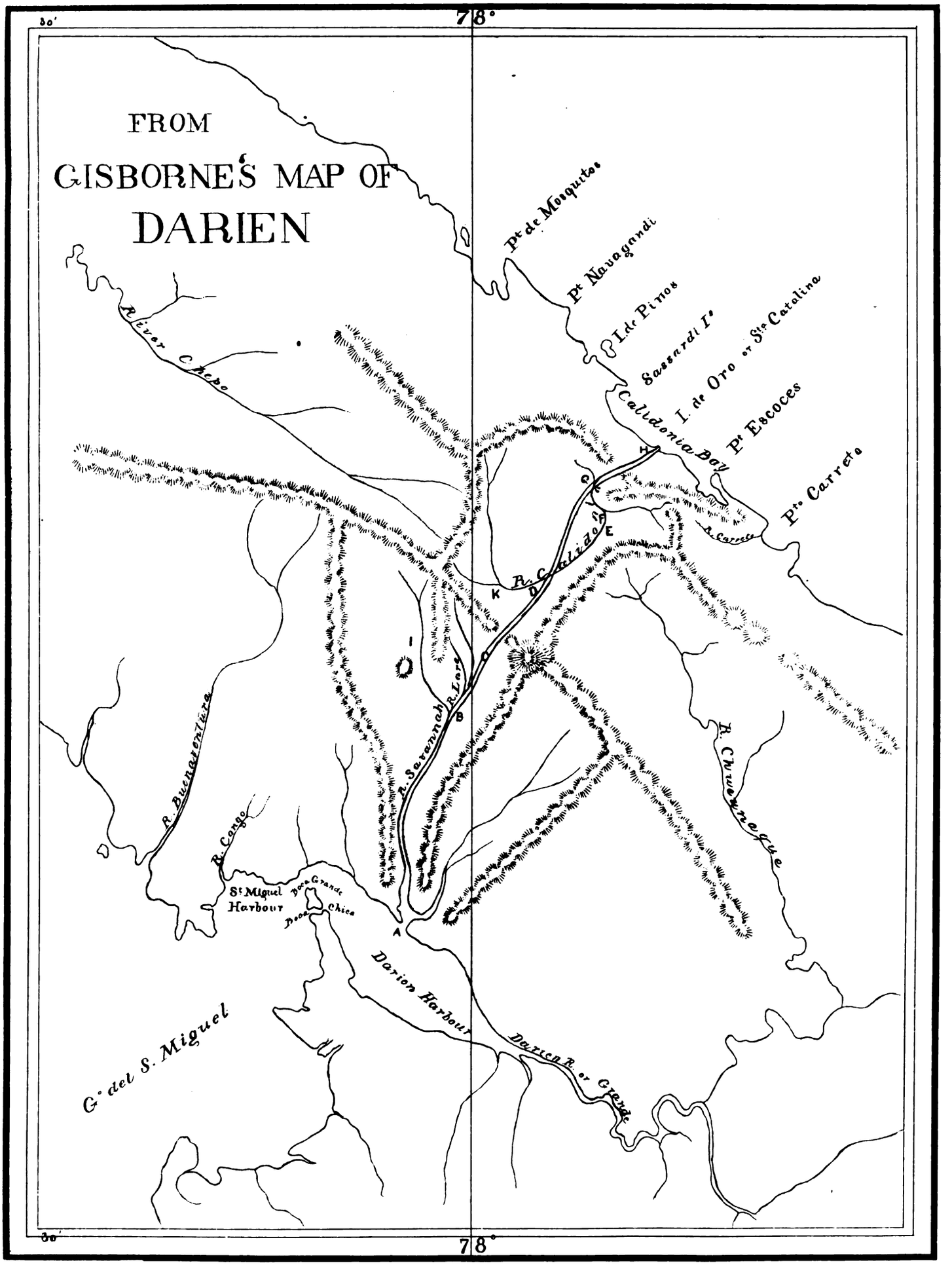

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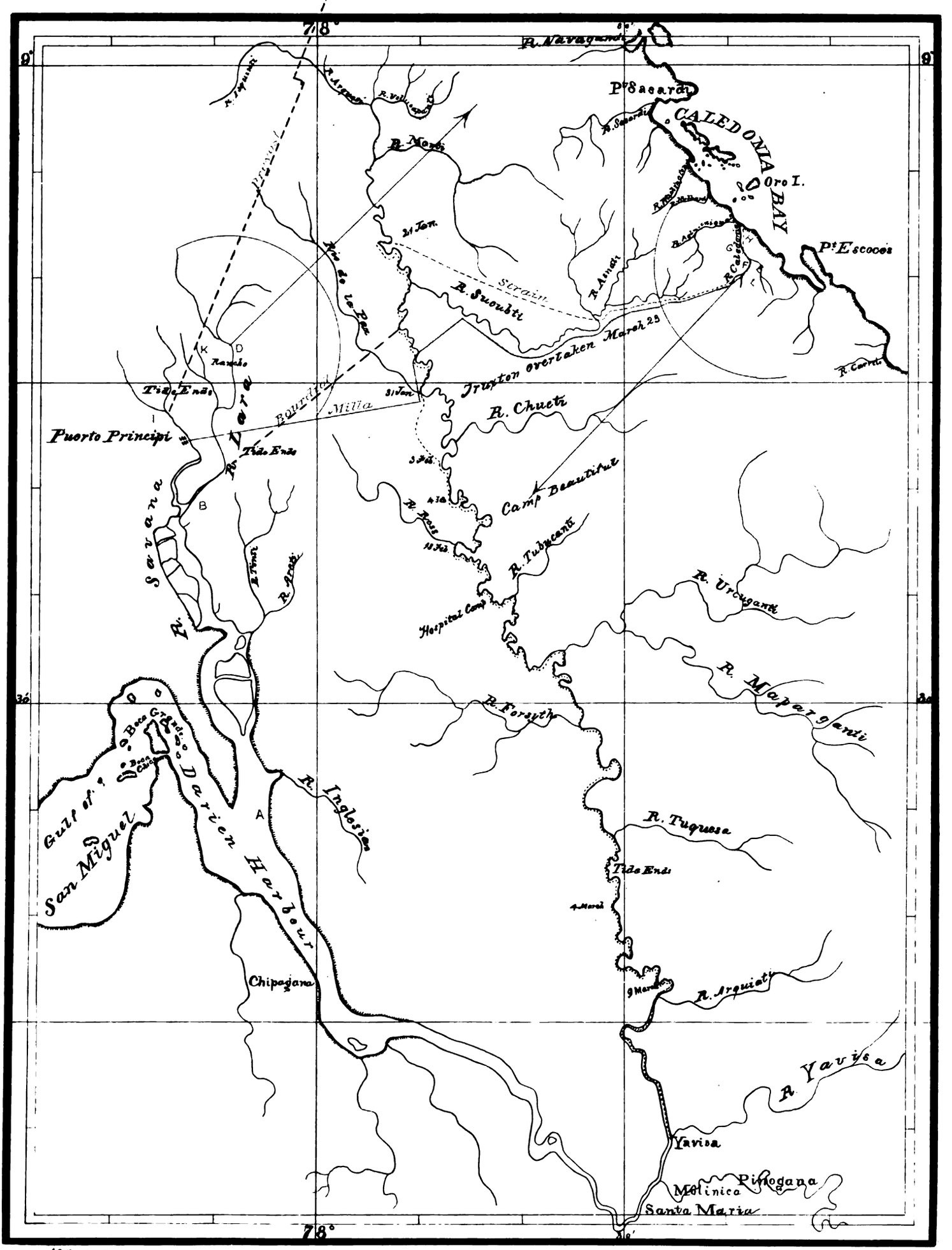

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Outline map of the Caledonia route illustrating Gisborne's error, Strain's journey, and reconnaissances made by Milla, Prevost, and Bourdiol.

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with an examination of the Savana River. "At its mouth we found it two miles wide, narrowing for seven miles above to a width of half a mile, and skirted by hills from two to three hundred feet high, running within a mile or two of its banks. The depth of the river varies from nine to six fathoms at low water, and soundings gave us a soft muddy bottom. From this point to the junction with the river Lara the depth diminishes till the bottom becomes level with mid-tide. The tide rises for five miles further up the Savana, to a fall of about two feet over a stratum of rock crossing the stream diagonally northeast by east at a dip of 60°. The point marked I in the accompanying map shows how far we were able to ascend in a canoe. The same class of rock appears both at the bottom and the sides. The course of the Savana beyond tidal influence is tortuous, the width of the water-way being sixty feet at I.

"On the morning of the 2d July we began our land journey to the northeast in the direction of Caledonia Bay. For the first two miles the country was level and less overgrown than on the Atlantic side, which made our progress comparatively rapid. * * * We then crossed a range of hills which we ascertained to be 100 feet high, forming the summit between the Savana and Caledonia Rivers; at the foot a small stream flowed nearly due east. We followed it for two miles, which led us to a larger one, the course of which we traced to the point marked D on the map. At this point a clear view to the northeast in the direction of the point marked E, towards Caledonia Bay, showed a flat plain with no intervening hills. The points D and E being only six miles apart, our view from D towards E, and our still more commanding view, for at least six miles from an elevation of 100 feet at E, in the direction of D, overlapped and were perfectly conclusive with regard to the few miles seen and not actually walked over. We therefore accepted the admonition of a foot-path and a bridge formed by the trunk of a tree placed across the river at this point, that we were again in the territory of the Indians into whose hands we had fallen at Caledonia Bay, and that, our object being accomplished, it was unwise to incur further risk from the Indians by walking over these six miles, thinking it best for the sake of the undertaking to retrace our steps at once."

From these observations, Gisborne arrived at the following conclusions: That the actual breadth of the Isthmus between the tidal effects of the two oceans was 30 miles; that the summit level was ascertained to be 150 feet, and that it was formed by a narrow range of hills having a gradually rising plain at its foot on each side. He also believed that a more detailed examination of this dividing ridge would reveal a much lower summit.

All these conclusions were wide of the mark, and a comparison of Gisborne's map with one compiled from authentic sources will show at a glance what an imperfect conception he formed of the topographical features of the country. It will also appear that Port Escoscés being plotted 7 miles too far west, and the mouth of the Savana 10 miles east of its true position, brings them nearer to the same meridian than they should be, the difference in longitude being 12 instead of 29 miles. From these errors it will be seen that his fields of view not only failed to overlap by many miles, but that his lines of sight did not bear upon the points he supposed.

His great error was in his conclusion regarding the dividing ridge. He started out with the conception of a Cordillera unbroken by intervening valleys, and considered it important to ascertain the position of the summit of the divide relative to the coast lines. He states that it was generally believed to be nearer the Atlantic than the Pacific shore, and this is a fact, but when, after leaving Port Escoscés and crossing the ridge which lies between the shore and the eastern branch of the Caledonia River, he encountered the "small stream which afterwards led him to a larger one," he altered his views concerning the unbroken character of the Cordillera, and was misled into believing he could trace the valley of the river six or seven miles to the southwest, and judging from its size at the point of observation, that its headwaters must be ten miles away. If this were the case, he concluded that the river did not have its rise in the Cordilleras, but flowed through them in a sudden break from a low ridge nearer the center of the Isthmus. His reason for considering the ridge a low one was because the only hills he could see being to the eastward, he judged that the lands to the south and southwest were low, and that no mountain range formed at the head of this river. During his examination on the Pacific side he made a similar error, and, although he certainly did not intend it, he was in reality only giving form to a supposititious case he had conceived on shipboard.

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Dealing with the conditions as he supposed them to exist, he proposed two plans for the canal, one with and the other without locks. Both plans were generally above criticism and were boldly designed to meet the fullest requirements of the commerce of the world, and it is to be regretted that such talent was wasted upon a fallacious assumption of facts. Gisborne has been harshly handled for his unfortunate mistake, but it is highly probable that one as great would have been made by any one entering into the examination under the conditions which then existed.

On his return to England he had his notes of the journey published under the title of "The Isthmus of Darien in 1852," which furnishes information relative to his methods not otherwise attainable. A consideration of these methods will be beneficial in showing that he and many others who have gained the unwholesome title of distorters of facts do not strictly deserve the disgrace.

In this work he treats in a running style upon financial, political, religious, and scientific questions suggested by the incidents of the journey, and in such a manner as to produce a very favorable impression upon the reader as to the extent of his knowledge and the soundness of his views. Referring to the uses to which electricity would be applied, he says: "Before this century has closed, electricity will replace the pen, if not guide articulation, and will convert night into day. All that is wanting for the former is to make an instrument sufficiently delicate to indicate waves of sound; and for the latter, one that will preserve an uniform intensity in the evolution of electric light." These predictions, so happily fulfilled at the present day, give a value to his opinions, and at the same time increase the disappointment and regret that he was not equally happy in his conclusions regarding the character of the Isthmus of Darien.

The fatality that seems to be attached to the individual examination of the Isthmus is in no case more strikingly manifested than in that of Gisborne, and this fact suggests a consideration of the influences which misled these individual explorers. The great importance of a communication between the two oceans naturally incited motives of ambition and gain in many persons, but of the many a few only sought a personal solution of the problem; and it can be readily understood that these dreams of fame and fortune were more potent in producing imaginary than practical results. These influences, sufficient to warp the judgment under ordinary circumstances, produced virtual blindness to unwelcome facts in the case in question, and their effect is manifested by the glaring errors into which their victims fell.

As the result of his search for information regarding the country he was about to explore, Gisborne states "that scarcely a single fact relating to this Isthmus can be relied on; the writers seem to vie with each other in a series of contradictions, laying themselves open to the same charge of want of consistency by their obstinate and one-sided view of the particular scheme they have made their hobby."

With such a clear conception of the errors of others, it was to be expected that he would guide himself more carefully, but, in spite of all, he is found plunging into the same current; and while acknowledging the danger of inductive reasoning, he nevertheless allows himself to follow, as he says, "this false system," and with no better result than to find himself consigned to the class he so lately condemned.

Very unfortunately for these enthusiasts there could hardly be a place less suited to inductive reasoning than the Isthmus of Darien, for here nature's sway is so great that man is forced to slow and toilsome labors in fathoming her secrets. As far as the use of judgment is concerned in determining the orological features of the country, it is of no more avail than it would be in determining the contours of the bottom of a bay; the barrier being in the one case a dense forest, and in the other, of course, water; facts in either case being obtainable only by measurements.

Previous to his landing on the Isthmus, Gisborne formed a suppositious case of a route involving two good harbors as termini, and a summit level of 100 or 150 feet, with other equally favorable conditions. Subsequently he congratulates himself on his good fortune in finding that these conditions exist, but it will be seen from the limited extent of his examination that his observations on shore were hardly any more practical than his speculations on shipboard. Evincing, as he does in the work referred to, an ability to treat professional and other subjects fairly and to arrive at correct conclusions, his going so wide of the mark in the present case can only be explained by his reliance upon methods which were not applicable to a study of the Isthmus; but

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while his error may be considered as the result of his accepting as facts the product of his reasoning, Dr. Cullen is less fortunate, as it is impossible to relieve the mind from the impression that he was guilty of gross misrepresentation. This impression is strengthened by his failure to appear in the examination which Gisborne made, and evidently without any reasonable excuse for his absence. It had been arranged in London that Cullen was to meet Gisborne at Carthagena on the first of May, but owing to a delay in obtaining the concession, the appointment could not be kept; and as Cullen's services were considered valuable, it was decided to await his arrival from Bogota. Three weeks later the negotiations were concluded, ending the necessity for Cullen's presence in Bogota, and after an additional delay of three weeks, the prospect of his appearing upon the scene being as remote as ever, Gisborne sailed from Carthagena in a chartered vessel without him. He was exceedingly chagrined at Cullen's action, and was clearly of the mind that the latter was suiting his own convenience, causing him to dance attendance; but in this view he was no doubt wrong, as the action can be better understood in the light of Cullen's fear of exposing his ignorance of the country about which he had written so boldly and of which he knew nothing.

The importance given to the Caledonia route by Gisborne's favorable report to his principals led to arrangements for a detailed survey; and as the attitude of the Darien Indians was such as to cause fear for the safety of a small party, it was decided to overawe the Indians by a display of force, and then, by treating them in a conciliatory spirit, gain their assistance. For this purpose, and with the broad view that the undertaking should possess an international character, it was determined to seek from the leading naval powers such co-operation as would facilitate the object in view. The result of these efforts was to secure the presence of the following vessels at Caledonia Bay in January, 1854: U. S. S. Cyane, Commander G. F. Hollins; H. B. M. brig Espeigle, Commander Hancock; H. B. M. schooner Scorpion, Master Commanding Parsons; H. I. M. steamship Chimère, Lieutenant Commanding Jauréguiberry. H. B. M. steam sloop Virago, Commander Marshall, was on the Pacific side, in the Gulf of San Miguel, having arrived there on the 17th of December. Colonel Codazzi, chief of the topographical department of New Granada, was the representative of his Government.

Gisborne arrived in Caledonia Bay on board of the Espiegle, and was accompanied by Lieutenant St. John, R. E., and Dr. Cullen. His engineering staff, under Mr. Forde, was instructed to proceed via Panama to the Gulf of San Miguel and commence the survey from that point.

Although the above-mentioned vessels were present to assist in the undertaking, it does not appear that there were any stipulations between their respective Governments regarding co-operation. It is certain that the United States Government did not issue any instructions to the commanding officer of the Cyane of such a character; and the honorable Secretary of the Navy, J. C. Dobbin, rather permitted than directed the organization of Lieutenant Strain's party, the members of which he insisted shou'd all be volunteers.

Gisborne's favorable indorsement of the Caledonia route attracted a wide attention, which was the more easily secured owing to the awakened interest in the subject of interoceanic communication resulting from the discovery of gold in California and the construction of the Panama railroad. Many eyes were turned towards Darien, and among the first to seek a confirmation of Gisborne's statements was Rear-Admiral Fairfax Moresby, R. N., who issued the following order to that end:

"PORTLAND," AT CALLAO, *August* 4, 1853.

SIR: I inclose you a report addressed to Messrs. Fox, Henderson, and Brassey by Mr. Lionel Gisborne, C. E., also a book recently published by Dr. Cullen, both relative to the locality through which the Atlantic and Pacific Oceans may be united by a ship-canal.

On leaving Panama you are to take the opportunity of ascertaining, as far as may be in your power, the extent of the advantages set forth in these publications by proceeding to the Gulf of San Miguel and ascending the Savana to the point indicated by Mr. Gisborne's report, then crossing the Isthmus as far as you can without causing a hostile feeling on the part of the Indians.

The particular point on which further information is desired is on that portion of the Isthmus not actually trod by Mr. Gisborne.

If canoes are required they are to be found in the Bay of Garachiné. I send you an American chart of the locality, published in 1851 by Dr. Autenrieth, at New Orleans. You must be cautious

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in entering the Gulf of San Miguel. I recommend your not risking the navigation beyond the Bay of Garachiné before it is examined by your boats. Much prudence will be required in the performance of this service. Should the time prove unfavorable, or a prospect of delay beyond a week, it must be abandoned.

I am, &c.,

FAIRFAX MORESBY,
Rear Admiral, Commanding in Chief.

Commander J. C. PREVOST,
H. M. Sloop Virago.

Acting under these instructions, Commander Prevost proceeded in the Virago to the Gulf of San Miguel, where he arrived on the 17th December, 1853, and two days later started up the Savana with a party consisting of seven officers, twenty-one sailors, and seven natives, in a cutter, gig, and canoe. The party was well armed and supplied with fourteen days' provisions. He ascended the Savana to a point about twenty-two miles above its mouth, and being unable to proceed farther with the boats, disembarked his party on the left bank of the river, and made preparations for the land journey.

The object of this reconnaissance being, as indicated in the orders, to extend the examination of Gisborne's route so as to include the six (?) miles he had not walked over, it was intended to commence operations from the point which Gisborne marked D on his map. There being nothing to guide them to the location of this point, it was subsequently decided to lay off a straight course from Fuerte del Principi to Caledonia Bay, and, in following it, estimate distances. This course, taken from the maps, was north-northeast, but unfortunately it was not known that the terminal points were plotted with errors, both in latitude and longitude, so that the course selected was nearly 60° north of what it should have been, and, if followed to the Atlantic coast, would strike it at a point more than thirty miles away from Point Escoscés.

Prevost's plan was to push forward as rapidly as possible on this course, and open a well-marked trail, which could not be mistaken, and which would be of benefit to future explorers, Soon after the line had been started it was discovered that an estimated distance of three miles did not in reality exceed one mile. "This difference of opinion as to the actual distance gone over," says Prevost, "fortunately led to the measuring system. Had we not adopted it we might have been greatly puzzled, so easy is it for the most experienced to be deceived, owing to the density of the forest, the labor of cutting a road, and the total exclusion of the sun and sky from the path—besides the exertion of lifting the feet so high to clear the tendrils that even to the last day, notwithstanding a fortnight's experience, we could not judge our distance correctly within a half; and Mr. Kennish, who had been for years traveling in these countries accompanied only by Indians, was equally deceived."

The system of measurement adopted was by using a line one chain in length, and, though crude enough, it was the first that had ever been applied to this route; and the party was the first which possessed the valuable elements resulting from an organized and disciplined body.

Progress was slow and laborious, as can be judged from the fact that it required fifteen days to cut through twenty-six miles of the forest. By this time, having exceeded the limit of his stay, and having come nearly to the end of his provisions, he was compelled to retrace his steps without being rewarded by a sight of the Atlantic, although he had, during the last few days of his advance, momentarily expected it would burst upon his view. Had he been able to continue in the field, he would have been still further disappointed, as it would have required much hard work and nearly a week, at the rate he was proceeding, before he would have reached the desired shore; and then, as stated, not at Caledonia Bay, but many miles beyond it.

During the reconnaissance many attempts were made to gain a knowledge of the country beyond the sides of the narrow and hard-earned footpath, by sending men into the tree-tops, but from the confused reports of such observations it became evident that no dependence could be placed upon them. In the vicinity of their eighth encampment a view was obtained from a lofty tree and a depression reported bearing about east. This was, in fact, the depression of the Caledonia Pass, the point he wished to reach, but having no misgivings about the correctness of the course he was

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following, there was nothing to indicate that he should change it to one leading to this gap. The only circumstance to raise doubts in his mind occurred a few days afterwards, when he encountered the Chucunaqua, at Rancho 10, which, as he says, should have been left some distance to the eastward, steering the course he had, according to the maps then in hand.

At this river he divided his party, taking the most active with him and ordering the others to await his return. He hoped in the short time left to him by these steps to facilitate his reaching the Atlantic, but after reaching the heart of the Cordillera he was compelled to return.

On arriving at Rancho 10, where he had divided his party, he found no one there, and all the provisions and stores gone. The place had the appearance of having been ransacked, but there were no traces of Indians to be seen. "At first I concluded," says Prevost, "that the guard had gone back to No. 9, a quarter of a mile distant. Rancho 9 was soon passed, and in Indian file we came to the swamp, and then plainly distinguished the marks of Indian feet. Still, we were undisturbed, and had reached within a quarter of a mile of No. 8, when, in taking a short turn in the road, to my horror we came suddenly upon the bodies of three of our shipmates, lying dead in the pathway. My first impression was that they had fallen down exhausted with the weight they were carrying, as each had a load of provisions, so unprepared was I for so sad a termination to all our hopes. But in this I was soon undeceived, and the melancholy fact of the cold-blooded murder was too evident. Apparently they had not moved, but died without a struggle, while falling to the ground, mortally wounded by gunshot fired from the left-hand side of the road from an ambush, the density of the forest here, as everywhere else, making every tree a hiding place and shelter for as many Indians as chose to collect. The bodies of our poor fellows appeared in a sad, putrid state; apparently they had been dead about forty-eight hours. Nothing had been taken from them except their muskets, not even their bayonets or ammunition, and a quantity of rum carried by Hyde was untouched. Not a trace could we find of poor Robins, the fourth man.

"To linger longer in the neighborhood of such a dangerous ambush was only to risk other valuable lives, and although we had the desire, God knows, to give our late shipmates Christian burial, we had not the means, and believing it probable that the Indians had merely returned to collect a strong force and cut off our retreat, and might at that moment be pursuing us, we turned from the heart-rending sight and sought our own safety."

Pushing on by forced marches extending into the night, the party gained the ship on the following day. Retaliatory measures were entertained by the commanding officer of the Virago, but were not executed, as it was feared such a course would imperil the parties who were about entering from the Atlantic side. This action of the Indians, it was afterwards learned from the chief of another tribe, was owing to the fact that they had no intimation of the presence of foreigners in their country until they suddenly came upon them, and, not knowing their purpose, had treated them as all invaders had been treated.

Although Prevost failed to accomplish what he hoped for, he rendered a good service in stating only what he knew to be facts, and from the limited amount of information thus furnished showed how little could be gained from a reconnaissance without instrumental aid.

STRAIN'S EXPEDITION AND THE OPERATIONS OF ENGLISH AND FRENCH PARTIES IN THE VICINITY OF CALEDONIA BAY.*

The Secretary of the Navy, Hon. J. C. Dobbin, appreciating the magnitude of the work of an interoceanic canal, and the influence which its successful execution might exert upon the commerce of the world, accepted, December 12, 1853, with the consent of President Pierce, the services of Lieut. Isaac C. Strain, U. S. N., who volunteered to explore the route which, as has been shown, had been represented in England by the engineering reports of Lionel Gisborne, C. E., and by the previous statements of Dr. Edward Cullen, to be entirely practicable.

Lieutenant Strain had passed through several years of exploration in South America and in Lower California. The route now proposed to him for exploration, "so attractive and so highly commended in England, by not only capitalists and merchants, but by statesmen, offered to satisfy

* The account of Strain's expedition is the joint work of Professor Nourse and myself.—J. T. S.

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all the conditions required for a ship-canal on the grandest scale," and Lieutenant Strain, with his friend, Passed Midshipman W. T. Truxtun, received additional assurances of its practicability from an agent of an English company, who resided in the United States.

After several conferences at the Navy Department the Secretary of the Navy issued his instructions to Commander George N. Hollins, commanding United States sloop Cyane, to the following effect, viz: That he should receive on board the Cyane Lieutenant Strain, Passed Midshipmen Charles Latimer, and W. F. Truxton, with Assistant Engineer J. M. Maury, and any other persons, not exceeding twelve, whom Strain might desire to join him; and, giving them passage, proceed to the port of Carthagena, New Granada, and then deliver to the local authorities a letter from Señor Paredes, the minister from that State, resident at Washington; and that if the authorities of New Granada should confirm the opinion expressed in that letter the Cyane should receive on board such additional men, not exceeding twenty, as might then be selected; and, proceeding to Port Escoscés, in Caledonia Bay, land the party, with such of the Cyane's crew as might volunteer and be accepted for the expedition. Commander Hollins was instructed to place in the hands of Lieutenant Strain the orders of the Department, which required him to make as speedy a reconnaissance as possible of that part of the Isthmus of Darien which lies between Caledonia Bay and the Gulf of San Miguel, but that if any difficulty should be interposed by the Indian tribes Strain should resort to all just and proper means to persuade them to abandon their opposition, but avoid all infractions of international law, and retire from the undertaking unless it could be accomplished without unfriendly collision. The Department left with Commander Hollins the decision as to whether he should, in the absence of the explorers, make hydrographical surveys in the harbor of Caledonia or a cruise for the healthfulness of the ship. She was to bring the party back to the United States. In giving these instructions the Secretary considered that "the Cyane, which belonged to the Home Squadron, might, with great propriety, cruise in the region of Caledonia Bay, and, at the same time, convey any party who might volunteer to engage in an arduous exploration, which might prove beneficial to the commerce of the world, settle an interesting question, and, ultimately, exert a happy influence by bringing into closer commercial and naval proximity our Atlantic and Pacific coasts." In consideration of the views presented by Lieutenant Strain, the Department gave its sanction to the expedition and extended to it every facility. It was, however, to be purely voluntary, no orders being given for its organization, neither does the least intimation appear on record that it was designed to act in concert with any other exploration.

December 20, 1853, Lieutenant Strain reported to Commander Hollins, accompanied by the following volunteers, viz: Passed Midshipmen Charles Latimer, W. T. Truxton, and H. M. Garland; First Assistant Engineer J. M. Maury; civil engineers and assistants, W. S. Boggs, of Ohio; J. G. Kettlewell, of Baltimore; Sterret Hollins and G. U. Mayo, of Norfolk; Surgeon J. C. Bird, of Wilmington, Del.; and Messrs. Theodore Winthrop and ——— Holcomb, who would also perform the duties of engineers, but without pay.

The Cyane sailed from Philadelphia December 20, arrived at Carthagena on the 4th of the month following, and immediately communicated with the governor of the province, Señor Juan José Nieto, who replied that he was ready to give to the expedition all the assistance which "his legal attributes would permit—besides that which would be expected from a friendly nation," but suggested that it might be convenient to await the arrival of Col. Augustine Codazzi, Chief of the National Commission, destined by the Government of New Granada to explore the Isthmus, which would give to the expedition not only a national character but much useful assistance.

The Cyane having awaited the arrival of this officer nine days, and receiving the thanks of the governor for the delay, sailed for Caledonia Bay with an assurance from him that he would place the New Granadian explorer in connection with the American party seasonably on the Isthmus. Mr. Frederick Avery, a native of New York, residing at Carthagena, had joined them there, and Messrs. Ramon Castello and Bernado Polanco preceded them as Commissioners from New Granada, to explain the peaceable character of the expedition to the Indians.

The Cyane arrived at Caledonia Bay on January 17, five days before any of the other vessels mentioned, and a conference was sought at once with the chiefs of the Darien tribes residing near the coast. On the 18th a council with the Indians was held on board the Cyane, and although at first they tenaciously opposed the landing of the party, they finally gave their seeming consent,

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on condition that property and persons be inviolably respected. On the following day Strain received from Commander Hollins the Department's instructions, and immediately landed his party. The march, however, was delayed, owing to a loss of provisions sustained in the capsizing of a boat, and the night was passed in a deserted village on the beach. The company now consisted of the officers before named (except Garland, incapacitated by sickness), the two New Granadians, and thirteen men, volunteers from the Cyane; in all, twenty-seven. Each was armed with a carbine or musket, with forty rounds of ammunition; the officers having also Colt's pistols and fifty rounds. Every one carried a blanket and a haversack containing provisions for ten days, which Strain, depending upon the statements of Gisborne and Cullen, most unfortunately, believed would be sufficient to carry his party across the Isthmus and back. He had reason to expect that, once over, he could supply any deficiency from H. M. S. Virago, which he knew to be stationed in Darien Harbor, in connection with an English exploring party. The reconnaissance on which he now entered was to be only preliminary to a fuller one, the equipment for which was in part left on board the Cyane.

January 20 his work began, a small party exploring for paths on each side of the Caledonia River. At noon he loaded a boat with provisions and took it up stream, while the main body cut a path one and a half miles through the woods and canebrake. Continuing, they followed the windings of the river, which was generally shallow and clear. Three and a half miles from the beach the canoe was, of necessity, left near a deserted hut, which already gave signs of the distrust to be fully experienced on the part of the natives. The estimated descent of the river had increased from 5 feet for the first mile to 15 for the second, and to 30 for the third. The stream was also yet more rapid and clear, indicating its source in the mountains.

Early next morning the men crossed a ford, waist deep, and found the river divide, its eastern branch appearing the larger. (This was the stream which Gisborne followed down when he met the Indians.) Much to Strain's surprise, he already saw that the whole valley was inclosed by a semicircular range of mountains abutting on the Coast range, and forming a barrier with heights from 1,000 to 3,500 feet. Carefully examining the country, he could see no opening in any direction; yet, as Mr. Gisborne had stated over his professional signature that there was an elevation to be overcome of but 150 feet, and his maps were in hand, Strain was confident there must be some lower summit which he had not approached. He therefore continued at first to follow the eastern branch—the larger, and appearing the most likely to cut the Cordillera—until he found, at sunset, that it was leading him, by a series of rapids and cascades, away from the Pacific and into the highest of the ranges. While ascending this branch he had passed through a second deserted village, which he thought would hold as many as 800 men. Above this he met three Indians, one of whom endeavored to persuade him to leave the eastern branch and follow him towards the southwest, but Strain did not think this man was to be trusted. He soon, however, found himself compelled to return, as the stream became more and more rapid, tumbling over a rocky bed, and diverging still more to the east. An advance party came to banks yet higher and higher, with elevations of 200 feet, while the distance from the beach by windings was about 9 miles. This branch was at once seen to be utterly useless for any canal project.

Returning to the southwest branch, and ascending it the next morning, all progress there was effectually barred by a cañon too deep to be forded and having high precipitous banks. Two Indians here met them, bringing a letter from Commander Hollins, informing Strain that he had had an interview with an Indian called Robinson, a messenger from the San Blas tribes, and that the bearer would guide them to the Pacific; but either there had been some deception practiced, or, as seems more probable, Strain, in his distrust of the Indian, misunderstood him, and thought that the bearer of the message was desirous only that he should return with him to the beach. He took a letter back to the commander. Strain subsequently believed that this man would have led him to the Pacific.

The progress of the party now became more and more difficult, the rocks larger, the descent 70 feet to the mile, and the hills almost precipitous. Word was then given to scramble up the hill as each one best could, and rejoin on the stream beyond the gorge. The party, therefore, took different routes, some climbing the steep banks near the cañon, while Strain, with a majority of the officers, sought an easier ascent about 100 yards below. While ascending he discovered a faint

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Indian trail, which he felt confident led to the Pacific. He immediately made the customary recall of all his men, and, hearing the answer as coming from some distance up the river, supposed the answering party were only looking for an easier ascent to rejoin him, and so continued on the westward trail, which carried him over the divide; descending its westward slope, he came to a stream which, according to the maps of Gisborne, was a branch of the Savana; it was the Forti, tributary to the Sucubti. He had crossed three peaks on the trail, the highest of which was estimated to be 1,500 feet, and the lowest 1,000; this lay on his left, and was utterly impassable. One of his men climbing a tree to obtain, if possible, a view of the country, could report nothing in sight but mountains on mountains. On the Sucubti he awaited until the following morning the coming of the five for whom he had signaled, but, despairing of their joining him, and "feeling the importance of pushing on as rapidly as possible," he left a note for them and continued to follow the stream; it led him into the depths of the forest.

The five who had been unable to rejoin him, Holcomb, Winthrop, Bird, Hollins, and the seaman Roscoe, crossed the hills and regained the river beyond the gorge. Awaiting here for some time the arrival of the main body, whom they supposed to be following, they continued to ascend the stream on which they were, three miles farther, when, coming to a division of the stream, they left a note for Strain, and took the west branch. On the following day, finding this now becoming a mountainous torrent, tumbling in cascades through a wild gorge in the porphyritic rock of the chain, and assured that the main body could no longer be in advance of them, they encamped. The distance they had made was estimated to be by its windings about 17 miles; the elevation gained, 700 feet. Engineer Winthrop's notes read:

"We have here impenetrable forests, dense and dark; lofty mountains; no Indians; very little animal life; no game; no snakes; no mosquitoes.

"Hoping to have an extended view of the country, we cut to the summit of the Cordillera, 800 to 1,000 feet; but, from the top of a tree there, saw nothing but similarly wooded mountains, broken only by the valley of the stream. As we have no compass in our party, we decided in council that it would be only daring to start off into the forest. We therefore retrace our steps down the stream; we find our notes untouched. Returning to the gorge, we find no clew to the meaning of their having turned off from the main route appointed. We judge it necessary for us to return to the ship, by way of the river, and reached it at sunset."

On the beach they met the English and French parties who had landed on the 24th from the Scorpion, the Espiegle, and the Chimère. The parties combined numbered forty-nine persons, thirty-six of whom were armed. The officers were Lieutenant Preston, Mr. Edwards, and Assistant-Surgeon Edwards, from the Espiegle; Lieutenants Jauréguеberry and Oron from the Chimère; Colonel Codazzi; Lieutenant St. John, R. E.; Dr. Cullen, and Mr. Gisborne. They received Winthrop's report with great surprise, but the returning party, although they had advanced but about eight miles inland, having each evening heard the Cyane's gun, had learned enough of the Isthmus to report to these new-comers, and to the commander of the Cyane, that the plain described by Gisborne does not exist; that they had found the Cordilleras a broad mass of porphyritic rock, heavily wooded, from the highest point of which no open country could be seen. Both branches of the Caledonia followed up had been found to be rapid streams having their sources in great elevations.

Winthrop's report occasioning grave fears for the safety of Strain and his men, Commander Hollins on the following day equipped a small force under Lieut. C. M. Fauntleroy, well supplied with provisions, to relieve and recall the party, if possible; suggesting to Strain, in a letter sent, that he would do better if he returned, and, if necessary, renew the attempt with a fuller equipment. When writing of this afterwards to the Secretary of the Navy, Commander Hollins gave as his chief reasons for sending this party out, that he was satisfied from his own personal observation, as well as from the accounts received, that erroneous statements had been given to Strain, and that he had taken a wrong route.

On reaching the upper forks of the Caledonia, beyond the gorge, Fauntleroy detached seven of his party, including Winthrop, Holcomb, and Bird, well supplied with provisions, to search for Strain up the west branch. They followed this to the divide, and crossing over soon came into the bed of the Forti, and on the 26th, while following it, came upon the letter which Strain had

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left for them. In it he directed that if the separated party should not reach that place until late in the evening of the day of their separation, they would do better if they should return to the ship, for he would be too far ahead for them to overtake him. This, as has been seen, they had of their own judgment wisely done. Lieutenant Fauntleroy, with Mr. Hollins and eleven seamen, sought Strain by the eastern branch; his instructions also were to cross the Isthmus, if possible, by an unexplored branch of the Caledonia.

On the second day out he overtook the English and French parties who had started in with Colonel Codazzi; and, at the solicitation of Mr. Gisborne, Fauntleroy accompanied him and the chiefs of the other parties to the summit of a neighboring hill for a view of the whole country beyond; the sight was most unsatisfactory to all. Resuming the march, accompanied by Lieutenant St. John, they found the sources of the branch trending too far to the south and east to be hopefully followed; yet they pushed on, for now having entered the mountains there was no other way of penetration. Arriving at the direct source of the river, and then ascending the Cordillera, they found its summit not less than 3,000 feet; from a point 500 feet lower, a view offered itself of the Cyane in the offing, distant about 15 miles, estimated, the compass bearing being north 5° west.

The sight of the country from the west side of the range now decided their future course; for as far as the eye could see southward and westward, nothing came within a view which extended from 20 to 30 miles but ranges of mountains upon mountains. It was deemed totally useless to explore farther in this direction. Fauntleroy returned to the Cyane, which he reached in two days, taking back with him a store of provisions that Lieutenant, now Commodore, Pickering had left on his trail for the use of his party, should it have been needed.

The operations of the combined parties under Colonel Codazzi were limited to the valley of the Caledonia, and after three days Gisborne became convinced that the river did not pass through a break in the Cordilleras, but that they, on the contrary, formed a continuous range. "My original anticipations on this point," says Gisborne, "were thus disproved. It then became my duty to explore the main ridge of the Cordillera to search for a break through them. With this object the valleys of the Caledonia and Aglaseniqua Rivers and their tributaries were carefully examined, and several attempts made to cross the Cordilleras, but the extreme difficulty of moving about a large body of men among steep hills thickly covered with wood and intersected by deep ravines, made it evident that the Isthmus could not be thus crossed without great risk and danger, or suffering from want of provisions. After eleven days' exploring, the whole party (increased to one hundred and twenty by the addition of seventy New Granadian soldiers and convicts) returned to the ships."

The experience gained during this reconnaissance, proving the unwieldy nature of a large party, was particularly applicable to the force then in the field, as the number of different elements composing it must have added largely to its unwieldy character. In view of this experience, Gisborne determined to procure a guide and proceed on his reconnaissance with a small party. After many conferences, he succeeded in securing the services of the Indian Robinson to accompany Lieutenant St. John and himself, with two men, as far as the confluence of the Savana and Lara Rivers, where Mr. Ford had his headquarters. It was about this time that news was received of Prevost's attempt and its disastrous consequences, and it was feared that the contemplated exploration into that region would have to be abandoned; but Robinson gave assurances that no act of the Indians was to be feared, as they had entered into a treaty and guaranteed the explorers safety from molestation, which was not the case with Prevost.

Gisborne's plan received the sanction of the English and French commanding officers, and the party started on the 7th of February, carrying five days' provisions. He reached Ford's headquarters without accident, and during the reconnaissance received additional confirmation of the erroneous conclusions he had arrived at as a result of his first examination of the country. He ascertained the height of the pass in the Cordillera at the headwaters of the Caledonia to be 930 feet, and that the route was unsuited to such a canalization as would satisfy the demands of commerce. Arriving at the mouth of the Lara, he found that Ford had been obliged to leave the field on account of sickness; and, in consequence of the fear caused by Prevost's loss, it had been impossible to induce the inhabitants of Chipigana or Yavisa to assist in forwarding the surveys.

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The engineers were even abandoned by the sailors of the vessel which had been chartered at Panama.

Gisborne and party having crossed in safety, and the fact of having the Indian Robinson with them, inspired confidence to a degree, and arrangements were finally made at exorbitant rates for canoes and men to assist in the surveys. The country was examined on the line of Prevost's track and for one day beyond, in a northeasterly direction, without being able to reach the top of the Cordillera or any point from which the Atlantic could be seen. Deeming it imprudent to continue the reconnaissance in that direction, as they considered it probable that the Indians into whose country they would penetrate were uninformed of their presence, and might become alarmed, they returned to the Savana, all the party suffering from fatigue, and Gisborne quite disabled from the bite of a scorpion. Notwithstanding his condition, he made an effort to recross to the Atlantic by the route they had come by, but owing to a misunderstanding on the part of the Morti Indians, they did not have canoes at the mouth of the Morti at the appointed time, so he was obliged to retrace his steps and proceed to the Atlantic side by way of Panama.

Meeting with no traces of Strain, and convinced that he was not on his way to the Savana, Gisborne endeavored to induce the Morti Indians to give him canoes to descend the Chuchunaqua, as he felt sure Strain was lost along its banks. "Mr. Bennett had, by my instructions," says Gisborne, "arranged to proceed on this service, but when the time came, the Indians from Morti, who returned according to their promise to the Chucunaqua end of Prevost's track, refused to descend the Chucunaqua, stating that the country belonged to New Granada, with whom they were not on friendly terms. The authorities at Chipigana and Yavisa would in no way countenance an expedition to ascend the Chucunaqua, nor could men or canoes be engaged for this service on any terms. The arrival of the Virago renewed my hopes of finding Strain. Commander Marshall had received instructions to seek redress for the loss of four men of the Virago in January last, and to assist and protect the surveys. These duties were incompatible, and at his desire I wrote a letter urging the abandonment of 'seeking redress' and substituting 'the search for Lieutenant Strain and his party.'" Commander Marshall acceded to this request, and, after landing Gisborne and his assistants at Panama, returned to the Gulf of San Miguel, where a relief expedition was formed under Lieutenant Forsyth, who volunteered for the service.

THE SEARCH FOR STRAIN.

In the long interval elapsing since January 22, the latest date of any tidings from Strain, the efforts which had been made by Commander Hollins are best learned from his dispatches, including the reports from his officers. Their action had been substantially as follows:

March 3, Commander Hollins wrote to the Navy Department that several attempts had been made to communicate with Strain, both by detachments from the Cyane and through the agency of apparently friendly Indians, but without success, and that his last dependence had been on Mr. Gisborne, who left Caledonia Bay on the 7th ultimo, but on the fourth evening of his absence he wrote to Commander Hancock, of the Espiegle, that he was somewhat alarmed by a report received from an Indian runner that the French steamer Chimère had gone to sea, taking several Indians captive. On the rumor the guide had deserted the party, and they were surrounded by excited Indians, though Robinson was remaining with them. They could gain no satisfactory information of the missing party from the Indians, some saying that Strain was across the Isthmus, others that the whole party were devoured by wild beasts. Commander Hollins further said to the Department that, under these circumstances, he had determined to endeavor, by proceeding to Aspinwall and crossing to Panama, to clear up the mystery by instituting search, with the help of a few of his officers, on the Pacific side, and that Lieutenant Jauréguiberry, of the Chimère, had kindly placed his vessel at the disposal of Lieutenant Strain, if by any possibility that officer should make his appearance in Caledonia Bay during the absence of the Cyane.

For the decision to leave the Bay and search on the Pacific, Commander Hollins had the additional reasons that the Indians, who had generally appeared friendly and frequently visited the Cyane, had recently ceased their visits; that in no instance when parties from the ship had attempted to penetrate their country had they found any villages not burned or Indian property not abandoned;

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and that the New Granadian, Colonel Codazzi, who had gone inland five or six miles with a party of 120 men, had returned to say that he could not renew the attempt unless his force were increased to 500 men. The Secretary of the Navy, on receiving this dispatch, immediately ordered the commander of the Cyane to use all possible means and haste in the search, adding that he could not give credence to the rumor of Strain's party having been destroyed by wild animals, and that he was confident, from the intelligence possessed by that young officer, he would be found to have accomplished something of his important work. The Secretary's order was being virtually and effectually obeyed while it was on its journey to the Isthmus.

Commander Hollins, on crossing to Panama, deemed it advisable to send Lieutenant Fauntleroy to the Gulf of San Miguel to make a thorough search of its shores and the rivers emptying therein, giving him authority to charter a vessel, with men and provisions. At the same time Commander Marshall, of the Virago, officially informed Hollins that he purposed to proceed immediately to the Gulf and make careful search, sending boats up the Chucunaqua to the point which Strain had been last heard from by rumor. Commander Hollins having effected, as he believed, the best possible arrangements for the search on the Pacific, and being prompted to return to Caledonia Bay for new inquiries, left Aspinwall March 23, and, arriving at his anchorage on the 27th, immediately sent Lieutenant Pickering to endeavor to procure guides at the village of Sassardi. On the day following, Pickering, with a party consisting of Passed Midshipman W. K. Mayo and ten men, volunteers, proceeded up the Caledonia River under instructions to reach the headwaters of the Chucunaqua, and, if possible, obtain some news of the lost command. The search, on account of the scarcity of the ship's provisions, was limited to ten days. During the absence of this party Commander Hollins received a second rumor of harm to Strain's party in a letter from Lieutenant Fauntleroy, stating that an Indian had reported, from Chepo, eleven of Strain's men certainly devoured by wild beasts. By the 29th March Lieutenant Pickering had gained a point twelve miles down the Sucubti, when he was recalled.

In the mean time, Fauntleroy, at Panama, had met with a messenger from the Chepo Indians, who had come in to ask the protection of the governor for the friendly Indians, who, they feared, would be implicated in the massacre of Prevost's men. As the Virago was to institute a search in the vicinity of the Gulf of San Miguel, and believing it would be wise for him to seek news of Strain through the Chepos, who had communication with the tribes of the interior, endeavored, with Consul T. W. Ward, to assist the Indians' errand with the governor, but failed to find that officer true to a professed willingness to furnish the desired guarantee.

On the 14th of March, however, Fauntleroy left Panama on the search, accompanied by Mr. Charles Zachrisson, the Swedish consul, "a gentleman of family and fortune, who, forsaking the comforts of home, joined in the search as a volunteer." Arriving at Chepo, they found that the friendly Indians had passed through, avoiding observation. The natives of the village knew nothing of the massacre. The men, however, were now thoroughly alarmed at the news brought by Fauntleroy, and refused their assistance. He could get help from two boys only to convey them in a canoe up the Chepo, which they followed for 75 or 80 miles. All the way along information was obtained of the fugitive, and, at one place, of his taking with him all the young Indians indentured to the whites, and leaving word that any party following him would be killed should they meet. Proceeding a short distance above the river Canito, and finding all the settlements deserted, it was deemed fruitless to prosecute the search further in that direction. Returning, he arrived at Panama on the evening of March 26, and received the news that Strain had come out on the Gulf of San Miguel, and immediately communicated it to Commander Hollins through the United States consul.

Commander Hollins, receiving the dispatch by a chartered vessel from the consul at Aspinwall, Mr. G. W. Fletcher, recalled Pickering, and sailed on the 31st of March for Carthagena for a supply of provisions not obtainable at Aspinwall, detaching, however, from the Cyane Assistant Surgeon (now Medical Director) Peck, to take passage on the vessel returning to Aspinwall, and to report to Strain for duty. He bore orders for Strain to report on board the Cyane at Carthagena.

On reaching Aspinwall Surgeon Peck learned that no communication could be had with Carthagena until the 23d of the following month, and that as provisions could now be obtained at that port, wrote to Commander Hollins, suggesting that the Cyane should come to Aspinwall, and the suggestion being approved, the ship arrived there April 14. On the 16th Strain himself reported.

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STRAIN'S JOURNEY.

Strain, in the interval, had followed the Sucubti until the 25th of January, on which day he passed a deserted Indian village, the natives having continually hung around his path without opposing his march. Fording the river, he met on the opposite bank five natives. "The leader, who spoke Spanish, I recognized as having been on board of the Cyane, and among the men to whom I had offered a large sum of money if he would act as our guide. I had, therefore, every reason to believe that he had met us for the purpose of accepting our conditions, and had tendered his services in good faith. This opinion I have had no reason to change; but as they led us by a path from the Sucubti, I secretly gave orders that our route should be scrupulously noted by the officers, and that the trees should be marked by the rear guard, in order to facilitate our return in case they abandoned us."*

The next day's march was the most trying one they had yet endured. At its end they encamped on an island in a river which proved to be the Chucunaqua. They here met the Chucunas in force, and were refused a passage through their territory. The chief addressed a long speech to Strain, but the guide refused to interpret it, and stated that he must return to Caledonia Bay; that the Chucunas would guide the party to the Savana, which would be reached in two days, and would then supply canoes, in which they could reach Darien Harbor at the end of the third day. He not only refused compensation, but also refused to take a letter to Commander Hollins, and, with his four companions, suddenly disappeared in the forest, overawed by the Bravos.

On the 27th of January they were eight days from the beach, and Strain was informed that some of the men were totally without provisions; the two New Granadians had, during the first days of their journey, cast their supplies aside, unable to bear the burden. Ascertaining the truth of this, he ordered the officers to divide their food with the men, and then found that for the whole party there remained provisions for one day only. Plantains and bananas were abundant in the vicinity of the camp, but the Indians would neither sell nor give, and feeling bound by his promises to the chiefs on board the Cyane he determined to await a greater emergency before taking them by force.

Early in the morning five Chucunas appeared, armed with metal-pointed arrows, which they use only in warfare, pointed arrows of hard wood being used for hunting. From the moment they appeared Strain suspected them of treacherous intent, but did not deem himself justified in declining their services. They led him down the Chucunaqua about two miles, and then took a trail on the right bank which led to the westward. Guiding the party by this trail for some distance into the forest, they suddenly disappeared. The path was followed until it terminated at a deserted hut; from this point Strain retraced his steps, and with much difficulty found his way back to the river, where he determined to obtain the opinions of the officers and engineers in council. "We had no guides, but we had, on the other hand, seven days' hard march between us and the ship, and had, moreover, every reason to expect Indian hostility on our return. The moral effect of a retrograde movement upon our own party, whose pride revolted at the idea of a failure, had its influence upon the decision. We had served out our last provisions; but up to that time we had always found plantains upon the banks of the river, and had every reason to believe that the supply below would be ample for all our wants; for after the flagrant treachery of the Indians we felt ourselves no longer bound by the stipulations made on board the Cyane. In this respect our expectations were measurably realized, as for three days we obtained an ample supply of plantains and bananas from deserted plantations. The question which the council was called upon to decide was whether it was most expedient to march through the forest direct for the Savana, and thus incur the danger of perishing from thirst either on the march or among the mangrove swamps, which we were aware fringed its banks for more than forty miles above Darien Harbor, or to adopt the more cautious course of a tedious journey by the river on which we then were, and on the banks of which we expected to meet white inhabitants above the point at which the mangrove swamps and brackish water would be found. It was unanimously decided to follow the Chucunaqua, and all our subse-

* This quotation, and those which follow, are from Lieutenant Strain's paper on interoceanic communication, which contains much matter relating to the journey not found in his report to the Secretary of the Navy, called forth by ungenerous criticisms made by Codazzi.

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quent information proves that this decision was the salvation of the party. No proposition to return to the ship was made, and I believe that every one felt that a transit from sea to sea would satisfy the world as to the impracticability of the project for constructing a ship-canal and make our work complete."

From the date of the desertion of the American party, January 27, its record is that of a journey protracted far beyond their expectations; of privations, extreme sufferings, and even death, born with heroic fortitude. From the 27th to the 31st of January they proceeded along the tortuous course of the Chucunaqua, following its right bank, cutting their way with great labor through the jungle and subsisting upon the products of the deserted plantations. Encouraged by the seemingly rapid rate of progress, they attempted to shorten the journey by following compass courses across the bends of the river, and on their first attempt lost the river for three days. During this period subsistence was obtained only from a few wild turkeys, some smaller game, and a monkey. A small quantity of palmetto, or cabbage palm, and some acid palm nuts, the latter proving disastrous to the enamel of the teeth and the coating of the stomach, served to eke out the scant supply of food.

On the 4th of February a halt was made and two days spent in the construction of a raft, which, when completed, had sufficient buoyancy to support Truxtun, the two New Granadians, Messrs. Boggs and Kettlewell, and one of the seamen. Strain, with the main body, followed the banks until sunset, when a signal of distress called him to the raft. To his disappointment, he found it blockaded by a palosada—a dam of driftwood; he reluctantly ordered its abandonment. From that time until the 12th of February they continued cutting their way through the thick jungle. Game was scarce, and life was sustained principally by the acid palm nuts. Want of proper food and severe labor was now telling rapidly on the party. The rate of progress had diminished by the necessity for frequent halts. Feeling aware that all must perish before emerging from the forest at this slow rate of traveling, Strain took advantage of a halt rendered necessary by the condition of the New Granadians and devoted the afternoon of the 12th of February to the construction of a raft. The wood selected was the lightest that could be obtained, but upon trial it was found that though it would float it would support no additional weight.

At length, on the 13th, Strain determined, in order to save the main body, to advance in person for assistance, and called for volunteers, from six of whom he selected Mr. Avery, Golden, and Wilson, the strongest. Placing the party formally under Truxtun's command, he set out on his journey, and by the end of the day was gratified by thinking he had advanced 18 miles. This distance was greatly overestimated. On the 14th swamps and an impenetrable jungle impeded his progress, and in the evening he halted near some driftwood, from which he constructed a raft. Here he also found some acid nuts, which was the first food he had eaten for two days. Wrecked several times, and twice narrowly escaping with their lives, they were compelled to abandon the raft on the 16th and continue the journey by land. Boils and sores now made their appearance, and attacking their legs and feet, rendered their progress slow and painful. Mr. Avery suffered very much from this cause, but all were much debilitated, and Golden kept up with the greatest difficulty.

March 2, the river being found freer from rapids and snags, a raft was again constructed, with which they started on the 3d. At the end of the journey of the following day they were encamped near a shallow rapid, which, as they were thinking of the uncertainties still before them, suddenly ceased its murmurings and by its silence announced the incoming Pacific tide. Buoyed up by this happy revelation, the journey was hopefully continued. On the 9th of March, at a point 20 miles above Yavisa, some friendly Indians encountered the party and brought them into the settlement, originally an Indian mission established in 1747 by the Jesuits. The men who now sought its shelter, after twenty-four days' separation from their comrades, were almost totally exhausted through want of food and rest, their bodies wounded and sore, and scarcely covered with the remnants of clothing left to them.

Strain here learned that the Virago was in Darien Harbor, but expected to sail in three days for Panama. As it was all-important to intercept her, he accepted Mr. Avery's offer to return for the relief of Truxtun, and at once proceeded to engage men and canoes for this service. The difficulty in obtaining provisions prevented the relief party from setting out until 9 p. m. the following

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evening, March 10. The main party having had orders to follow the river by easy marches, Strain had no doubt of their being relieved and brought down before he could return from the Virago.

A scarcity of canoes compelled Strain to wait until the 11th of March before he could obtain transportation to Santa Maria, and at that place he obtained a canoe of sufficient size to navigate the lower waters of the river. On the 12th he arrived at Chipagana and learned that the Virago had sailed for Panama on the 10th, to be absent six days. He was also informed that the Atlantic and Pacific Junction Company, whose engineers and employés were under the control of Mr. Gisborne, had a depot of supplies on the Savana, at the mouth of the Lara. The violent wind that day prevented his obtaining boatmen willing to take him across the bay, but he was enabled to set out before daylight the next morning, and in the afternoon arrived at the depot, where he obtained provisions and money from Mr. W. C. Bennett. Returning, he arrived at Yavisa on the night of the 14th of March and awaited intelligence from the relief party. "That night and the next were passed in sleepless anxiety, but I was helpless. I could obtain no canoes or men, and by following up the river I was placing myself in a position where I would be powerless. Before daylight on the second night Mr. Avery suddenly burst into the house of the padre where I was domiciled. My first question was, 'Have you brought the party?' He replied, 'I have brought one; I have brought Parks.' His story was soon told. He had reached the point where we had encamped the first night after the separation, and which Truxtun had reached with the main body in four days; there, suspended on a cross which marked the grave of the first victim, Holmes, was a letter addressed to me, stating that as twenty days had elapsed, all hopes of my safety had been abandoned, and that, yielding to the solicitations of the party, he had determined to regain the Indian country, and, after recruiting, to attempt to reach the ship. Their condition was vividly portrayed by the expression, 'For God's sake, hasten after us, for we are nearly starving.'"

Avery had gained "hospital camp," when the sight of Holmes's grave alarmed the canoemen. Fearing the Indians, they refused to proceed; entreaties and pecuniary offers were unavailing, and the relief party, which was certainly within eight hours' journey of the main body, returned unsuccessful. On their descent, and about ten miles below the last camp, Parks, who had been accidentally separated from Truxton's party, was found in the last stage of exhaustion. He was almost delirious, and soon after arriving at Yavisa became thoroughly so, and died within a few hours.

Before it was yet light, Strain made arrangements with the authorities to send back the canoes with another party, which he demanded should be placed under military discipline, to insure, if possible, their obedience. Notwithstanding this precaution, he was unwilling to trust the safety of his party to such men as the natives had proved themselves to be, and leaving Mr. Avery and the padre to superintend the funeral of Parks, and the former with orders to push up rapidly with canoes and provisions as soon as the party could be collected, he hastened to seek aid from the Virago, which was expected to arrive in Darien Harbor. Eighteen miles below Yavisa he discovered the Virago's boat ascending the river with all the rapidity obtainable from oars and tide. "I now felt that my party was secure from danger, as savages could not intimidate so gallant a people as the English when bound on an errand of charity and mercy. It was to the promptness, energy, and kindness of heart of the generous Bennett that we were indebted for this prompt assistance, as the night previous, upon the arrival of the Virago, he had paddled himself some twenty-five miles in a canoe to give information of my arrival, the position of the party, and to request that men should be dispatched to our assistance. While alluding to this gentleman, whose liberality and generous services entitle him to the complimentary letter of thanks written to him by the Secretary of the Navy, gratitude demands that I should allude, at least briefly, to another evidence of his self-sacrificing disposition and anxiety to serve us to the utmost. The English officers, perhaps in view of the disasters of their previous expedition into the country, were instructed not to leave the river or their canoes; and as it at one time appeared probable that we would not overtake the party at a navigable point, he privately offered to load himself with provisions and accompany me through the forest until we had overtaken them, and this, too, although he had been expressly prohibited by Gisborne from attempting to cross the Isthmus, and was suffering severely from the gusano del monte, or wood worm, which had perforated his foot. This was the man to whose efforts we owe most for assistance, and, although not in a position to be bene-

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fited, as were the officers of the Virago, by the good offices of our Government, he will live long in the grateful memory of what Colonel Codazzi is pleased to call the 'unfortunate Darien expedition of the North Americans.'"

Strain embarked in the Virago's boat and arrived that night at Yavisa, where, after much difficulty, he obtained some canoes, and the next day pushed up the river. "Having now obtained reliable coadjutors," says Strain, "I was less anxious for the services of the New Granadian levy, but left orders for them to follow as soon as they could be collected. Eleven joined us the next afternoon, and soon after, meeting a rapid which the boat could not pass, she was left in charge of some eight men, while the united parties followed up the river with all the speed which could be induced by an exalted enthusiasm." The prospect was encouraging until the morning of the 23d of March, when the New Granadians again showed their fear, and notified Strain that they would on no account proceed further than that day's journey, end where it might. Reserving until occasion should call forth such means as he had to overawe them into obedience, Strain continued the journey, and soon after starting came upon the grave of Señor Castello, and stretched upon it was the dead body of his countryman, Señor Polanco. Saddened by this sight, and with misgivings as to the fate of the party, the relief pushed rapidly on until sunset, when, on turning a bend of the river, they discovered a portion of the party on the bank. "Three hearty cheers passed along the line of canoes, which was instantly responded to by a similar Anglo-Saxon expression of joy and welcome from the suffering party."

Upon landing, those who were immediately upon the bank crowded around Strain to express their satisfaction at the arrival of relief, and of his own safety, of which they had despaired. Only one showed much excitement, occasioned by a high and noble anxiety to know whether, in his dire position, and with the responsibility of the party resting upon him, he had done what was best for the general welfare. "Immediately after landing, Mr. Truxtun rushed toward me, threw his arms around my neck, and sobbing from the effects of concentrated emotion, said, 'My God, captain, did I do right in coming back?' Several were enfeebled to the last degree, and at least four would never have marched from the spot, but all had made a march of several hours that day, and there was nowhere an evidence of despair. The two who were most feeble, and subsequently died, expressed their gratification at my safety, and, with a noble generosity seldom paralleled, appeared to merge their own sufferings and dark prospects in the satisfaction they felt at the relief which had arrived for others, accompanied as it was by one who, whether deserving or not, possessed their confidence and was mourned for as dead. It is difficult to restrain my indignation when reading such an attempt to brand the members of my party as despairing imbeciles and lost to all feeling save the animal instinct of self-preservation, when I remember that dying men who could scarcely raise their attenuated arms to take my hand concealed their own danger and suffering to avoid giving me additional pain. One who survived, but was unable to rise from the ground, respectfully touched his hat and expressed his pleasure at my return, remarking at the same time that it was fortunate for him and four others that I had returned, as they would not have been able to proceed the next day. Another, two days after, asked me to shake hands with him, and apologized in a feeble voice for not being able to raise his arm from the ground, but expressed himself hopefully as to his recovery. When I knelt by the side of my old and tried friend, Mr. Boggs, and begged him not to feel dispirited, as we had all of us now the means of safety, he replied, with a feeble pressure of his hand, 'I do not think I shall die now, captain, but it is fortunate for me that you have arrived, as I should not have been able to go on to-morrow.' Upon our arrival, the journal of the day had been written, and in it was expressed the expectation of making a long march on the morrow. The five whom I had first greeted on the river bank had gone down with the intention of bathing. The camp-fires had been lighted, one for the men and the other for the officers, and fuel provided for the night. Even in their extreme distress, distinction of rank was carefully preserved, and though the officers assisted in forming a camp for the men who were less able to endure extreme fatigue and deprivation, common misery had not leveled distinction, as is so generally the case in extreme suffering. The condition of things elicited from the English officers the remark that 'this was the perfection of military discipline.' If I write with feeling upon this subject, I beg that I may be pardoned, and that it be remembered that I am not writing of myself, but of the gallant and enduring band who had been confided to my care."

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Those who had died were Holmes, Parks, Costello, Polanco, and Lombard. The death of the last named casts perhaps the deepest shade on the whole picture. Stern necessity had brought about the unanimous decision that he who should, from time to time, prove totally unable longer to march, must, for the common safety, be abandoned, and it came to the turn of Lombard, once one of the strongest of the Cyane's crew, to have this decision against himself. Strain says: "That last scene in life's drama of a faithful servant of the Government, and a just man, deserves a pen superior to mine. I can appreciate, but cannot describe it. Lying on the bank within reach of the water of the river, with a tin pot to supply his wants, and a fire near him, he awaited a decision which involved not his life only, for that he was aware was well-nigh sped, but the companionship which had thus far sustained him, even in the depths of misery. Although it had been unanimously determined many days before that those who could not march with the party should be abandoned to secure the common safety, it was hard to part with an old and tried companion, and a council was called to decide upon his fate. Each man, commencing with the lowest in rank, was called upon to give his opinion, and as each gave his fatal vote he took an eternal leave of the suffering man, with whom he divided his scanty food. Of all the party the victim was the most calm and self-possessed. His will had been already made, and being duly signed, was committed to the charge of Mr. Truxtun, when all the party withdrew, save one who remained to pray with him. These last offices concluded, his last comrade tearfully wrung his hand, fell into the ranks, and the word 'Forward!' was the last human sound that reached the ear of the dying man."

The wants of the survivors were attended to promptly, with certain judicious restrictions, and nurses were appointed to attend to them during the night. They were separated from each other to prevent a too exciting conversation, and every means taken to prevent excesses. Tobacco was the thing most craved for, and Strain remarks that it was the first thing asked for by himself and other members of the advance party upon their arrival at Yavisa. The survivors were all on their way down to the river early next morning, and the reunion of all was effected at Yavisa on the 27th. Another victim, Philip Vermilyea, was, however, buried the same evening. The rest of Truxtun's men, quartered in the little village of Palmas, near Boca Chica, were carefully attended to by Surgeon Ross and other medical officers of the Virago. After making the fullest provisions for their immediate necessities, Strain proceeded to Panama to arrange for their transportation. As previously stated, he reported to Commander Hollins on the 16th of April, and having received the funds needed to complete his arrangements for the sick, he hastened his return to Palmas; on his way down, however, he met them coming up in one of the Virago's boats. Arriving again at Panama on the 23d of April, he sent the sick forward to Aspinwall, with the advantage of an easy journey of at least two days, while he remained at Panama with Mr. Maury to await the result of the illness of Mr. Boggs, who died at the American hospital on the 24th. On the following day Strain and his companion returned on board the Cyane, which vessel soon set sail for New York, where she arrived on the 17th of May. The officers and men belonging to the expedition had recruited as rapidly as could be expected of men who had spent sixty six days in the forests of a tropical climate, and had been subjected to the extreme privations which have been related. Commander Hollins immediately received from the Secretary of the Navy his congratulations on the safe return of the survivors, with the testimonial that "his zeal in carrying out the orders of the Department, and his activity in endeavoring to tender aid to Lieutenant Strain and his party, met with the warmest approbation of the Department."

The crew of the Virago's cutter each received $100 in gold from the Department in remembrance of their services in the relief expedition; their commander, Lieutenant Forsyth, was, on the official representation to his Government, promoted. The services of Mr. Bennett and those of the medical officers and of Paymaster Hills, of the Virago, were gratefully acknowledged first by a letter from Strain and afterwards by the Department.

As to the results of the expedition, Strain says: "We claim to have clearly dispersed a magnificent and dangerous fallacy, which had already cost many lives and swallowed up a large amount of capital. We further claim that our difficulties and sufferings have prevented even a greater loss of life by continued expeditions, saved immense pecuniary losses, and caused the quiet dissolution of an association combining the first names in Europe, with a capital stock of $75,000,000."

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The value of this very hasty attempt will be differently estimated, according as the decision is formed as to how much was thereby effected toward eliminating the route from future exploration. History is full of seeming failures, not always failures, since they clear the path for other and subsequent examinations. In so far as this was accomplished by Strain, his dashing journey cannot be said to have been fruitless. It was not, however, of that character safely called even a reconnaissance which would satisfy the public mind or the formation of new plans for this part of the Isthmus.

Gisborne had, in the meanwhile, returned to Caledonia Bay and found the Espeigle, the only vessel there. With his engineering staff a reconnaissance was carried forward by the Aglaseniqua over the divide and into the valley of the Asnati. The only detail of this work given in the summary of his report is the height, 1,013 feet, of the lowest point of the dividing ridge between the sources of the above-mentioned rivers. It is not mentioned by what means the data were obtained, but it is presumed they were furnished by barometrical measurements. Arrangements were made to cross from Sassadi Village over to the Morti River, but it subsequently transpired that the headman of Sassadi collected forty or fifty of his men and refused permission to enter by that route. The lateness of the season rendered it unwise to take up the work in any new field, and arrangements were made for the return to England. The unfavorable results obtained were treated by Gisborne in a professional spirit and accepted as proving the impracticability of the route for the purpose intended.

Cullen's scheme received a blow which should have been its death, but its author had the boldness, in face of facts, and of the misery and loss of life for which he was largely responsible, to reassert, with certain modifications, the practicability of this route.

BOURDIOL'S SURVEY.

Notwithstanding the evidences of Cullen's unreliability, furnished from so many sources, M. Roger, of Paris, enthusiastic over the Caledonia route, called him to his side and entered into arrangements for the development of the line and formation of a company. Soon after the concession was obtained and the preliminary preparations made for the survey of the line, M. Roger found his scheme and credit imperiled by Cullen's demand for 60,000 francs, in hand, before he would reveal the locality where the depression in the Cordilleras existed. Fortunately for M. Roger he was enabled to sever his connection with Cullen, and maintain the dignity and honesty of his own purpose.

In the interest of interoceanic communication by the Isthmus of Darien, M. Roger founded and administered the Société d'Études. Under the direction of this society an attempt at exploration was made in the vicinity of Caledonia Bay, but nothing was accomplished.

Subsequently, in April, 1861, Mr. Bourdiol, as engineer-in-chief, joined a party of fourteen persons sent out by the society to make an actual survey from the Pacific side to Caledonia Bay. This was the first expedition to this region which employed instruments of precision. Work was commenced at the mouth of the Lara, and a course (N. 49° E.) followed which it was supposed would strike the Chucunaqua near the mouths of the Sucubti and La Paz. The progress of the work was interfered with by the roughness of the country, and rarely, under the most favorable circumstances, could they advance more than 1,500 meters in a day. The party remained five or six days in the same camp, and, day by day, moved forward to fix themselves in one which they were constructing farther inland. The season was unfavorable, the rains often forcing them to suspend work. In the midst of this rough life the negroes, whose services were very precious, began to tire, and became daily more and more afraid of Indians, whose trail had been already recognized. The instruments used were a compass, chain, and level, and the principal line was worked out by the transverse levelings of a measured length. The party was soon reduced in numbers through fatigue, hardship, and sickness; some returning to the Balandre, their little vessel, and others to Panama, and on the 9th of May the negroes deserted in a body, alarmed by indications of the presence of Indians. "Their abandonment of us," says Bourdiol, "left us in a very difficult position, not as to our security, for we knew we could not count upon them in case of danger, but because the strength of their arms was wanting to go before us, open up the route, and transport

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our food, instruments, and necessary materials. Nevertheless, we continued to advance so long as we should not be arrested by insurpassable obstacles. Every one of us took up the most laborious work without regard to persons, and our good-will made up for our loss of numbers. But our strength was giving out; occasional injuries and the insect bites, more serious than they had at first appeared, compelled us to rest in consideration of our grievous sores. The levelings and different operations were not interrupted, so that after twenty days we had finished the work of getting over the basin of the Savana and Chucunaqua, the altitude of which is about 65 meters.

"More than a month of our forest life had now passed. Our party, composed at first of twenty-five men, was now reduced to seven, of whom several began to be at the end of their strength. Lost in the immensity of the forest, thrown upon our own resources, with no hope of assistance, counting only on ourselves, or, I should say, rather, each counting only on himself, we were compelled, by force of circumstances, to learn to endure everything. Men accustomed to the influences of civil society experience, when thus thrown upon themselves, sensations strange, but not lacking in a charm which enlivens still more the splendor of nature. In these unremitting conflicts, the body is hardened, the senses acquire an astonishing acuteness, the energies are exalted, and man becomes conscious of the reality of his powers. A life of adventures in these rude countries offers some compensation, always to be remembered, sometimes regretted."

The work was now in the vicinity of the Chucunaqua. The rains were fully set in and interfered with progress; the streams and ravines overflowed, forming real torrents, and threatened to cut off their retreat. Desirous of carrying their line to the Chucunaqua every effort was made, but the accumulation of water flooded their path and made it difficult to avoid straying from it. A vigorous effort to effect a reconnaissance was made, and in order to find their route on the return over the inundated plain, the members of the party were placed at intervals within hearing "as so many living beacons," and an advance in this way attempted. The efforts were vain, as night approached and they were obliged to cease operations. A few days later, the floods having subsided, they were enabled, after a comparatively easy march of some hours, to reach the Chucunaqua. It was estimated that they struck the Chucunaqua a little above the Sucubti and La Paz, but they really came out below the former and much above the latter. The elevation of the Chucunaqua at this point, as given by Bourdiol, 29 meters (95 feet), is substantially the same as that given by Cadozzi and Gisborne, but does not agree with the elevations subsequently determined by Selfridge, who found the elevation of the mouth of the Sucubti to be about 146 feet. The difficulties which Bourdiol encountered in prosecuting the survey and the fact that the level line was not complete to the Chucunaqua may account for the error.

The exploration ended here; it was impossible to go farther; the party was used up and the supplies exhausted. Returning to France, M. Bourdiol, who evidently appreciated the necessity of full data by his attempts to secure them, made the common and fatal mistake of using the few he had obtained to unfold a project and estimate its cost. His canal was to be 31 miles long, and to overcome an elevation of 144 feet (!). Twenty-two locks were required, eleven on each side. The total cost was to be $34,000,000.

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CHAPTER VIII.

KELLEY'S SURVEYS AND TUYRA ROUTE.

To Baron von Humboldt belongs the honor of calling attention to the Atrato routes, but the credit for their earliest investigation belongs to Mr. Frederick M. Kelley, of New York, a gentleman whose name is honorably and inseparably connected with the problem of interoceanic communication, who, while still a young man, with an acquired fortune, sought through study the means of making useful to mankind his wealth and leisure. In 1851, while studying the scientific history and geography of Central America, he became impressed with the force of Humboldt's observations on the subject of interoceanic communication, and appreciating the importance of the problem, determined to apply his time and means to its solution. He entered upon his researches with the conviction that a canal without locks, if practicable, would be the only one that could satisfy the demands of commerce, and to this conviction he remains steadfast to the present day.

Humboldt's legend of the Raspadúra Canal, which, it was claimed, connected the headwaters of the Atrato and San Juan Rivers, and was navigable for canoes during the rainy season, led him to believe that this locality merited close study. With this view he sought and secured the assistance of other gentlemen, and they together engaged the services of J. C. Trautwine, C. E., a gentleman of high professional attainments and with an extended experience of engineering works in Central America, to make a study of this route with reference to the practicability of constructing a canal available for steamers of about six feet draught.

In executing this work Trautwine had two assistants, Dr. Mina Halsted and Mr. Henry McCann, and made use of the following instruments, viz: Aneroid barometer, thermometer, compass, tape-line, Locke's hand level, and the spirit-level. His examination included a careful study of the Gulf of Darien, and the bars which impede the entrances of the several streams which form the delta of the Atrato, also an account of these streams and of the river itself to its headwaters. From here he crossed the dividing ridge at three different points, and examined both the Baudo and San Juan Rivers throughout their length. Between the Pato and Baudo the dividing ridge was found to be over 500 feet high, and between the Santa Mónica and San Juan the line of levels "showed that the bed or bottom of the San Juan at San Pablo was 103 feet below that of the Santa Mónica at the Tambo of San Pablo, or head of canoe navigation; and that the lowest intervening ground at the summit between the two is about 183 feet above the former, or 80 feet above the latter." In view of these results Trautwine says that "it must be self-evident that the idea of a ship-canal cannot be entertained for a moment. * * * Among the principal difficulties to be encountered in the construction of even a canal for small boats, of say three feet draught, is, first, that the San Juan is 103 feet below the head of canoe navigation on the Santa Mónica; and that the lowest depression in the dividing ridge between the two streams is about 183 feet above the former, and about 80 feet above the latter. We therefore should have (on the most economical mode of proceeding) 103 feet of lockage, in connection with a long cut of some 80 or 90 feet in depth at the center, and a reservoir for supplying the summit level. Besides these, the Santa Mónica would require a good deal of improvement, as before hinted; as would also the upper portion of the San Pablo, before they would be available for a tolerably regular system of navigation by boats of even three feet draught."

The canal of Raspadúra "was in reality a hill, across which canoes were dragged, as they now are, not only at that point, but at many others in this region. A canoe was so transported at one of the partition points at which I crossed, and at the same time. I was at San Pablo in 1852, or but sixty-four years after the date given to Humboldt as that at which the Cura's canal was dug; yet persons living near the spot, both before and ever since that period, told me they had never heard of it; nor did I meet with one out of more than fifty persons familiar with the Raspadúra

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locality that had. This is not to be construed into a proof that no ditch was dug, but merely that it was a work of such entire insignificance as to create little or no impression even in a region where internal improvements are entirely unknown."

Trautwine's results were secured by excessively hard work and under the unfavorable conditions of being obliged to depend upon the resources of the country for food and transportation, but their accuracy and fullness indicate his ability, energy, and conscientiousness. As an observer and reporter of facts, whether for or against, he has not been excelled by any explorer on the Isthmus. The discouraging results, however, caused Mr. Kelley's associates to abandon the scheme, but he retained the hope that a more extended examination of the region between the headwaters of the Atrato and San Juan would reveal better conditions connecting the two oceans. Taking the burden of expense upon himself, he caused two studies of the region to be made in 1853; one by Mr. Porter and the other by Mr. Lane, but with no better results than were obtained by Trautwine, whose work was entirely confirmed.

Baffled in this direction, he turned his attention in 1853 to the western tributaries of the Atrato, between its headwaters and the Truando. He says:* "I left nothing untried in these directions, sparing neither expense nor scientific resources, but, being baffled again, at the suggestion of Mr. Lane I fell back upon the Truando, convinced that there or nowhere in the whole range of Central America were the proportions of a ship-canal to be found. This river was explored by Mr. Lane as far as the Saltos, but his health failing he was compelled to return. I then fitted out another party under Captain Kennish. Their instructions were to search for a good harbor on the Pacific, and, if possible, for a favorable place where, by a clear cut or tunnel, that harbor might be connected with the Truando and Atrato Rivers, at such a level as to admit of nearly still water all the way, with depth and width sufficient to enable steamers, men-of-war, and merchant ships of heavy burden to pass from ocean to ocean without detention and upon an even keel.

"Those only who have embarked their fortunes, time, and hopes of honorable distinction in great enterprises, can imagine the tremulous anxiety with which I waited for tidings from this party under Captain Kennish, which went out in 1854. Franklin was not more delighted when he drew the lightning from the clouds, or Columbus when he discovered America, than I was when it was demonstrated, by instrumental measurements, that the two oceans could be united; that all the science, industry, enlightened enterprise, and generous expenditure lavished upon this great field of investigation had not been exhausted in vain. Men of the highest intellect and moral elevation, such as Columbus and Humboldt, had foreseen the importance of this passage, sought and prayed for it; Cortez, Pizarro, and Balboa, as they pursued across the Isthmus and along the shores of both oceans their schemes of discovery and of conquest, could scarcely believe that the great Creator had not somewhere provided a highway between the Atlantic and Pacific through that narrow thread of land which seemed hardly to divide them. From their day to ours, in all commercial countries, deep solicitude had been shown for the discovery of this passage. Men of science had searched for it; brave and energetic men had perished in those enterprises; governments and public companies had vied with each other in endeavoring to secure facilities for the annually increasing commerce of two mighty oceans, which the stern aspects of the Cordilleras had hitherto turned aside. How could I believe that the Disposer of Events had crowned my humble labors with success? How could I fail to fear that my engineers might be deceived; that the resources of the scientific world might yet dispel the illusions to which, as though they were realities, I fondly clung? I went to England and submitted my plans and reports to the Royal Geographical Society of London, and to the British Institution of Civil Engineers. I invited the searching criticism of those most competent to judge in the mother country. I went to France, and, knowing how deep an interest the Emperor Napoleon had taken in the promotion of similar enterprises, and how profound a knowledge he had displayed of the general subject, at a time when correct views were confined to a limited circle, I laid my plans and surveys before his Imperial Majesty, and invited to their consideration, in the most public manner, the highest science in the service of the Government and people of France. I went to Berlin, and frankly explained to that illustrious sage, the pioneer of all scientific knowledge of Central America, the general views which I entertained, and the nature

* The Union of the Oceans by Ship-Canal without Locks via the Atrato Valley. Frederick M. Kelley.

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of the evidence by which they had been confirmed. In those three enlightened countries I was not treated as a stranger. There was a grandeur in the design of which I was the bearer, a dignity in the mission with which I was charged, that won for me courtesies which, on mere personal grounds, no stranger going to Europe for a first time could have anticipated or claimed. From the Emperor of the French, from Lord Clarendon, from Sir Richard Murchison, from Baron Humboldt, from Rear-Admiral Beechy, from Robert Stephenson, Admiral Fitzroy, and the members generally of the Royal Society and Institute, I received great kindness; and, what was of more importance, they applied to my plans and reports in a catholic and courteous spirit, but with a rigid exactness due to science and their own high reputations, those tests suggested and fortified by their great experience. A friendless and unknown American citizen was treated by these men as though he was a brother, not because he was eminent in science, but because they recognized in him the zeal, the prophetic hope, and self-devotion which are ever the handmaids of science.

"While the honest criticism or kind consideration of those elevated and enlightened men strengthened and encouraged me, I felt that they had laid upon me a new obligation; I was bound to give to them, even more than to the world at large, the best evidence of the sincerity and honesty of my purposes, and of the skill and integrity of the agents I had employed. I could only furnish this evidence by the aid and through the instrumentality of the Government of my country. The Hon. James Buchanan was then our minister to England. That distinguished man not only discharged towards me the duties of hospitality and courtesy to which perhaps as an American citizen I was entitled, but he encouraged me to hope and to apply for the verification of my own Government; and one of his first acts, when the suffrages of the nation had placed him at its head, was to facilitate the passage of the law under which that verification has been obtained.

"To secure, upon the authority of officers pledged by their reputations, no less than by the obligations of their official positions, to accuracy and good faith, a confirmation of my views, and of the accuracy of my engineers, was the last and highest duty which I owed to the scientific world, to the engineers who had aided and advised me, and to those friends who, in Europe and America, had shown me countenance and given me support. That duty has been discharged."

The Congress of the United States realizing the importance of the enterprise, and stimulated to take the lead in prosecuting the necessary explorations, passed an act, which was approved March 3, 1857, by President Buchanan, making an appropriation for that purpose. Section 10 of that act reads as follows:

"*And be it further enacted*, That the Secretaries of War and Navy be authorized, under the direction of the President, to employ such officers of the Army and Navy as may be necessary for the purpose, to make exploration and verification of the surveys already made of a ship-canal, near the Isthmus of Darien, to connect the waters of the Pacific and Atlantic by the Atrato and Trundo Rivers: *Provided*, That the expense shall not exceed twenty-five thousand dollars, which are hereby appropriated therefor out of any money in the Treasury not otherwise appropriated."

The project which had been reported upon favorably by Kennish, depended upon the practicability of turning a portion of the waters of the Atrato into the Pacific, thus forming a new arm or river flowing with a moderate current through a tunnel under the Cordillera. The principles on which this was to be executed are:

First. That the mean level of both oceans is the same.

Second. That the tidal wave at the mouth of the New River, on the Pacific shore, oscillates 12 feet 6 inches at spring tides, and 10 feet 11 inches at neap tides; while at the mouth of the Atrato (the terminus of the passage on the Atlantic) the tidal wave does not exceed 2 feet at any phase of the moon.

Third. That the waters of the Atrato, at the point of junction with the New River, are 15.2 above the mean tidal level of either ocean.

Fourth. That the junction or summit of the New River is, therefore, 9 feet above the Pacific at the highest tide, and thus the water will flow down it with a velocity equal to that head; while at the lowest tide the velocity will be equal to 21.45 feet head.

In accordance with the act of Congress, a portion of which is given above, Lieut. Nathaniel Michler, Corps of Topographical Engineers, United States Army, and Lieut. T. A. Craven, United States Navy, were detailed to execute the work of verification. This arrangement was a clumsy

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one, as it left the question of command unsettled, to which each officer, jealous of his rank, laid claim. The direction of the survey was placed in the hands of the Secretary of the Navy. On the return of Lieutenants Michler and Craven, he decided in reference to the claim to report results that, as they had been appointed to co-operate together, as a joint commission, they should report severally if unable to concur in a joint report. The former course was adopted, Michler favoring the route while Craven condemned it. Of these two opinions, Michler's was certainly entitled to first consideration, not only on account of professional fitness to interpret the data bearing upon the immediate line of canalization, but because these data had been secured under his direction and supervision, whereas Craven had been engaged in the hydrographical work of the survey, and not having access to Michler's field notes and measurements, his knowledge of the line was limited to that gained in passing over it to and from the Pacific side. His judgment was not at fault, however, in estimating the obstacles to the work, and while he felt that human ingenuity and perseverance might overcome them, he was of the opinion that the construction of the proposed canal was "impracticable, as involving an expenditure of treasure not easily estimated, and a sacrifice of life from which the stoutest heart may shrink." The actual physical difficulties were summed up by him under the following heads:

1. A cut through some five miles of submerged mud at the mouth of the river, with the prospective certainty of constant dredging to keep it open.

2. The herculean labor and incalculable expense of cutting through the lagoons of the Truando and the imbedded logs of the Palosadas, where the whole country is inundated during at least nine months of the year, and where the floods of a day may destroy the work of weeks.

3. The immense expense attending the removal of basaltic rock, in a country where labor and provisions must all be imported at most extravagant rates.

4. The want of an anchorage on the Pacific coast.

5. The fatal climate, which it may safely be estimated will disable, at all times, one third of any force sent there.

The result of Michler's work is a general verification of the feasibility of the project proposed by Kennish. In points of detail many of the latter's measurements were found to be in error, but inasmuch as Kennish had been unable to use instruments of precision on a great part of the line, this was not so surprising as that he should have estimated so closely. He placed the mouth of the Truando at 15.2 feet above the mean level of the sea. In the computation which gave this result he used 67.75 miles as the distance from the mouth of the Truando to the Gulf of Darien, whereas the correct distance is 75.25 miles. Making the correction due to this difference in distance, the resulting height obtained is 23.9 feet, while that found by Michler's survey was 25.75 feet. This height is for a low stage of the Atrato, and at an extremely high rise of water, or freshet, when the banks are overflowed, it reaches to 36.5 feet.

The route proposed by Michler differs materially from that suggested by Kennish. By reference to the map, it will be seen that the general course of the Truando, from its mouth for a distance of about 23 miles by its meanderings, is nearly parallel to the Atrato. A straight line drawn from the point where the Truando makes a considerable bend to the northward, and perpendicular to the general direction of the Atrato, is about 7.5 miles in length and strikes the latter river at a point 22 miles above the village of Sucio. This is considered the summit point, and is computed to be 32 feet, at a low stage of the Atrato, above the level of the sea. In extreme high water it would be 10.77 feet higher, or 42.77. On account of distance saved, and because the current in the New River would not exceed that of the Atrato, but rather fall below it, Michler selected this summit as the initial point of the canal cut. It was proposed that this cut should follow the line above described, across the swamps to the Truando, then follow the general course of the river to the mouth of the Nercua, a tributary of the Truando, and thence a short distance up the Nercua to the mouth of one of its tributaries, the Grundo, where it leaves the Nercua Valley, and, after piercing the Cordillera with a tunnel 12,250 feet in length, strikes the Chuparador, on the Pacific slope, and follows that stream to the Paracuchichi, which leads it to the ocean.

The dimensions of the canal were to be 100 feet at surface of water and 30 feet deep; the height of tunnel 100 feet above water surface. Michler estimated the cost would be $134,450,154.

The labors of Michler and his able scientific staff were not only accompanied by the many hard-

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The Truando-Atrato route.

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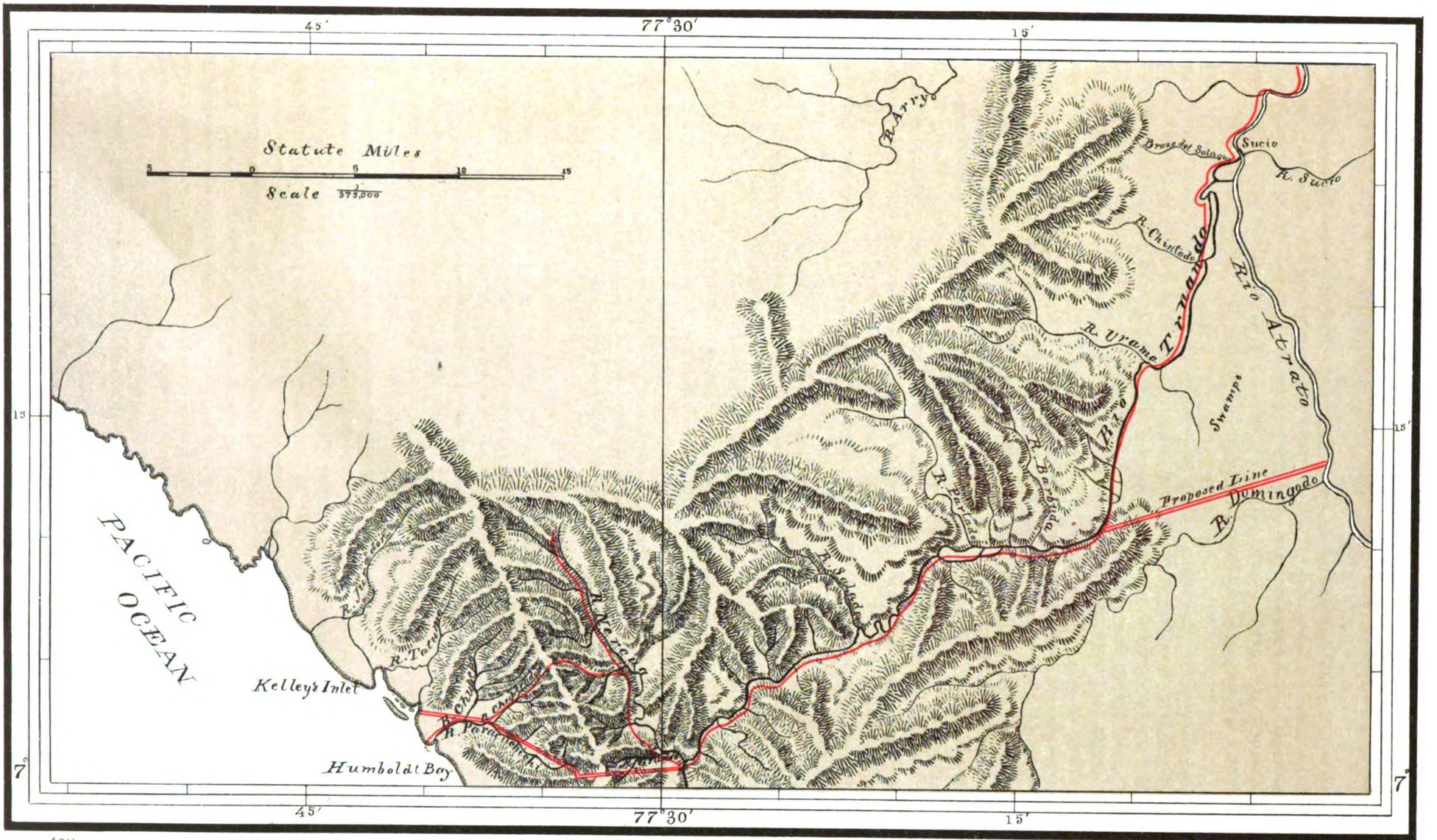

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ships incident to the country, but, owing to the unsuitable packages for transportation into which the provisions were made up, and to a deficiency in quantity and quality, much embarrassment and some distress resulted. Notwithstanding these drawbacks, the work was pushed to completion, and the resulting line was the first in the Atrato Valley that could base its claim of practicability upon full and reliable data, and, moreover, was the first line pronounced feasible for a canal without locks or dams.

An important and disappointing result established by Michler's study of the Truando route was, that the cost of the contemplated work would amount to nearly twice that estimated by Maj. E. W. Serrell, on the data furnished by Kennish. This unwelcome fact, together with a knowledge of many difficulties which would attend the development of the project in that locality influenced Mr. Kelley to seek elsewhere for better conditions. His chief objections to the route were similar to those advanced by Lieutenant Craven. They were: "Its great length; the necessity of creating a harbor on the Pacific coast; the almost impossibility of controlling the flood waters of the Truando Valley, and the difficulty of effecting and keeping open an entrance into the Atrato River by any system of engineering without the prospective certainty of everlasting dredging.

"In addition to the foregoing objections," continues Mr. Kelley, "the more deeply I studied the subject, the more clearly I saw that the increasing size of ships, the vast and rapid accumulations of wealth, the gigantic growth of trade all over the world imperiously demanding the shortest and most direct lines of travel, would, sooner or later, demand and cut a deep, wide sea-level canal across the narrowest part of the Isthmus, cost what it may; therefore, what was the use of wasting time and money on any long route either with or without locks?"

The narrowest part of the American Isthmus inviting his study was that lying between the Gulf of San Blas, on the Atlantic, and the mouth of the Bayano, on the Pacific. There was hardly any doubt as to the mountainous character of the intervening country, but the usual legends existed about low passes and of communication by canoe from one shore to the other. Before commencing a survey of the San Blas route, Mr. Kelley sent his oldest engineer, Mr. Rude, to make a barometrical reconnaissance of the Tuyra route. The results not being encouraging, he sought through Col. G. M. Totten, then chief engineer and superintendent of the Panama Railroad, information relating to the feasibility of making an open and thorough-cut on the Panama route. Colonel Totten stated that it would be impossible to build a canal by that route without introducing ten or twelve locks, and that the Chagres River could not be turned from its bed out of the way of a canal. This opinion being sustained by Mr. Kelley's engineers and others who had been on the ground, he gave up the idea of a canal at Panama without locks, and proceeded to ascertain the characteristics of the Isthmus in the vicinity of San Blas.

The only previous attempts to survey this route were made by Mr. Wheelwright, in 1837, and by Mr. Evan Hopkins, a few years later, but were not carried far enough to be of any value, the attitude of the Indians in each case preventing extended explorations. Some information, however, was gained, and, profiting by it, Mr. Kelley sent Mr. Rude, in 1863, to make a barometrical reconnaissance, in order to obtain approximate heights and distances. This was followed in 1864 by a regular survey executed by Messrs. A. McDougal, C. A. Sweet, J. E. Forman, and N. Rude, under orders from Messrs. Kelley, Cyrus Butler, and Luke T. Merrill.

The line of survey was from Chepillo Island, in the Bay of Panama, to the mouth of the Bayano; up that river to the Mamoni, which was followed to its junction with the San José. The line was carried up the last named river to the divide, crossing which it entered the valley of the Mandinga (?) and proceeded towards the Atlantic until within an estimated distance of about 2 miles from the Gulf of San Blas, when the work was abandoned on account of the hostile force of the Indians and the desertions which occurred from the party. This unfortunate interference of the Indians has been the source of much annoyance, as the uncompleted line could not satisfy all questions relating to this interesting section. However, many attractive features were developed, and it was considered that the canal would not be longer than 27½ miles, but the tunnel involved would be 7 miles long. In view of an apparent difference in the results claimed for this route by this survey, and by that subsequently executed by Commander Selfridge, the details of the line will be considered in connection with those shown by the latter survey, and later in this work it is proposed to make a technical comparison of the routes which merit such attention.

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The San Blas survey ended the series of field studies under Mr. Kelley's direction, which gave to the world for the first time positive data from the mysterious regions of Darien and the Valley of the Atrato. To have thus advanced the development of the problem entitles him to the highest consideration in connection therewith, and it must be added, as a measure of his public spirit, that in his researches he expended from his own means the sum of $125,000.

TUYRA ROUTE.

In closing the subject of the earlier explorations in Darien, a brief reference only will be made to the projects of De Puydt, Gogorza, De Lacharme, and Flachat, involving a line of canalization to connect the Gulf of San Miguel with the Gulf of Uraba or Darien. These explorations were of a very imperfect character, and belong to the Gisborne class of failures.

De Puydt, in 1861, when making an examination of the Tuyra and of several of its tributaries, came to the conclusion that in the eastern part of that valley "the elevation was sufficiently low, or else the rents in the mountains sufficiently deep, for the construction of a navigable water-way suitable for all kinds of vessels of whatever tonnage." Subsequently, in December, 1864, in the interests of the "Columbian Canal International Company," he undertook an exploration from the Gulf of Darien, by the Tanela River, to find this pass. His examination was a brief one, and the only measurements which he reports are those taken to obtain the velocity of the river at different points, with a view to a determination of its rate of fall, from which he could estimate the height of the "threshold of division." The result of calculations based upon these valueless data made the height 101 feet, but, allowing for the insufficiency of details furnished, he was of the opinion that the correct height above the level of the sea would be found to be above 150 feet. As might be expected, this elevation is very much lower than that which really exists.

In 1865, Señor Gogorza discovered a map and documents in the Spanish archives which indicated the existence of a pass through the Cordillera, at the headwaters of the Panusa, a tributary of the Tuyra, which would be suitable for the purposes of an interoceanic canal. Obtaining the co-operation of capitalists in Paris, an expedition was organized and placed under the charge of M. De Lacharme, C. E. M. Flachat was appointed by the "Compagnie Générale Transatlantique" to verify the work of this survey. Not finding the party ready for the field on his arrival at Panama, and pleading the limited time at his disposal for the work, he started off on an exploration of his own. This was regarded by Gogorza as an usurpation of his rights to the discovery of the pass.

M. Flachat made a hurried reconnaissance up the Tuyra, first to the mouth of the Pucro, and later up as far as the Panusa. His facilities for securing information regarding the country were very limited, but he made good use of such as he could command, and succeeded in gaining sufficient knowledge of the locality to satisfy himself of the immense obstacles which would be encountered in any project for canalizing the Tuyra route.

M. De Lacharme was instructed to examine the indicated passage by the river Panusa. Señor Gogorza intended to accompany him, but he finally resolved to remain at Panama. Arriving at the confluence of the Paya and Tuyra Rivers, De Lacharme was led by several considerations to abandon the route marked out for him and to select that by way of the Paya River to the divide; thence by the Cacarica River to the Atrato. His confidence in the course decided upon was increased by an incident which occurred shortly after entering the Paya River. He says: "Having killed a pisisi duck, I heard one of my interpreters, who had lived for some time at Paya, say that at a certain season of the year flocks of these ducks passed over Paya, directing their flight toward the sun-rising. I asked some questions on this point, and was satisfied that these ducks, according to their habit, were seeking a lake where to pass the summer; and as these water birds never fly over high ground if they can proceed by way of valleys and water-courses among the hills, there remained to me no doubt but that at this place I should find the desired passage."

M. De Lacharme proceeded up the Paya, and followed the route indicated to the confluence of the Chelepo with the Cacarica; here he felt obliged to end his excursion, not having boats to convey him to the Atrato. He was satisfied that a canal could be advantageously located on this route, and that it would be only 50 miles long; that 14 miles on the Pacific side and about 6 miles

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on the Atlantic side would be excavated through alluvial soil; and that the summit level near the village of Paya would be only 190 feet above the level of the sea. He placed the height of the divide at 290 feet above the sea, and gave its base the modest dimension of not more than 656 feet through from slope to slope. Judging from the results of De Lacharme's observations, it would seem that the pisisi ducks had proven themselves good guides, but, unfortunately the observations were imperfect, as was proven later by precise methods, and this ruined the reputation of the ducks.

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CHAPTER IX.

EXPLORATIONS AND SURVEYS ON THE ISTHMUSES OF PANAMA, NICARAGUA, AND TEHUANTEPEC PRIOR TO THOSE EXECUTED BY THE UNITED STATES ISTHMIAN EXPEDITIONS.*

PANAMA.

The possibility of a canal across this narrow part of the Isthmus had been before the minds of men perhaps most prominently of all the lines from the time of Balboa's crossing to the South Sea to Garella's survey in 1844. Until the explorations and surveys by Lloyd and Falmarc, in 1828, and the more complete surveys by Garella, no survey was made during the intervening three centuries; neither the relative height of the two oceans, nor that of the highlands between them, nor the geographical points even of the Isthmus had been determined.

The surveys to be noted are those made by Lloyd and Falmarc, for General Bolivar, in 1828; by Garella, under sanction of Louis Philippe, 1844; by Mr. J. C. Trautwine, C. E., and Col. G. W. Hughes, in 1849, and by Mr. G. M. Totten, in 1857. The last-named three were made in the interest of the Panama Railroad Company.

LLOYD'S LEVELINGS—1828–'29.

In May, 1828, under a special commission from General Bolivar, Mr. Lloyd, in connection with a brother officer, a Swede in the colonial service, commenced their work, although the rainy season had already set in, at a point in the suburbs of Panama, from which he followed the old road to Porto Bello until he struck the Chagres River. This was effected after 732 pairs of levelings in a distance from Panama of 1,828 chains (22½ miles). The greatest elevation he had passed over was 633 feet.

On February 7, in the next year, during the dry season, work was resumed and the line advanced to a point in the Chagres 12 miles from its mouth. The survey was arrested at this point because, although its primary object was to ascertain the most eligible line for communication between the two seas (by road or canal), a secondary but important object was to "determine the relative height of the ocean on either side." The point reached, La Bruja, was considered to be the high-water level of the Atlantic at Chagres. In regard to the relative levels of the two oceans Lloyd reported:

I. The mean height of the Pacific at Panama, 3.52 feet above that of the Atlantic at the mouth of the Chagres.

II. At high water the Pacific is raised above its mean level 10.61 feet, and the Atlantic above its mean level .58 feet.

III. At low water both seas are the same quantities below their respective mean levels.

As regards interoceanic communication he reported that "the spot where the continent of America is reduced to nearly its narrowest limits, being distinguished by a break for a few miles in the great chain of mountains (otherwise extending to the northern and southern limits of the Isthmus), points out a peculiar fitness for establishing a communication across."

The details of Lloyd's work, with his plans and maps, were deposited in the library of the Royal Society, but not published. A large part of his work was reconnaissance merely.

It is proper to state here that a series of observations made by Colonel Totten, the superintendent of the Panama Railroad, show that there is really no difference between the mean levels of the two oceans. A system of careful levelings over the finished road-bed of the railway, from sea to sea, in connection with a series of tidal observations at the terminal ports, showed that the mean level of the Atlantic was from about one-tenth of a foot to seven-tenths of a foot lower than

* The contents of this chapter were derived mainly from the manuscripts of Professor Nourse.

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the mean level of the Pacific, and this difference, Colonel Totten says, is probably owing to local circumstances alone.

There is, however, a very great difference in the range of the tides at the terminal ports. At Aspinwall the highest tide amounts to only 1.6 feet, while at Panama the greatest rise is 21.3 feet. The result of this difference in the range of the tides is that sometimes the Pacific is higher than the Atlantic and sometimes lower, but at mid-tide they are on a level.

SURVEY BY NAPOLEON GARELLA.

In consequence of representations from Messrs. Salomon & Co. that a route was practicable across this section for a canal without locks, by an open cut from sea to sea, M. Guizot, when premier of France, "decided to study the problem on the same line in regard to which they had received such surprising accounts from Salomon," etc. The French Government, therefore, sent over M. Garella and his assistant, M. Courtines, "Conducteur des Ponts et Chaussées," with instructions to study the question chiefly in regard to the nature of the obstacles to be surmounted, the means to be employed, and the cost of such an enterprise. The chief points therefore reported upon were:

I. The depression in the Cordillera, between Porto Bello and Panama, upon the representation made as regards the summit level of 12 meters, said to have been found by Morel. Garella says he despaired of finding this long before approaching the point. He reported from successive observations elevations from 120 to 160 meters as the lowest on the line.

II. The water supply could be secured by means of two lateral canals.

III. In order to save expense of lockage a tunnel of 5,350 meters was found necessary. This was proposed at an elevation of 99 meters, 325 feet, below the highest point of the mountain, the summit line for a distance of 25,361 feet being 135 feet above high-water of the Pacific. The number of locks was thirty-five. The estimated expense for a canal 66 feet wide at bottom, 98 feet at surface, and 12 feet deep, was $6,600,000, designed to accommodate vessels of 600 tons.

COLONEL HUGHES' SURVEY FOR PANAMA RAILROAD.

On the completion of the contract between the Government of New Granada and the Panama Railroad Company, an experienced party of engineers under Col. George W. Hughes, United States Topographical Engineers, was sent down to survey and locate the road. Colonel Hughes confirmed the reconnaissance previously made by the engineers, who had been under Messrs. J. L. Stephens and J. L. Baldwin, in their discovery of a gap of not more than 300 feet elevation. A yet lower opening was also found and the line located from Navy Bay to Panama.

The summit grade on this road is 258 feet above the assumed grade at the Atlantic, and 242.7 feet above the assumed grade at the Pacific terminus. It is 263 feet above the mean tide of the Atlantic Ocean, and the summit ridge is 287 feet above the same level. The maximum grade is 60 feet to the mile.

The total length of the road is 47 miles, 3,020 feet; of this distance 23⅞ miles are level and 28⅝ straight. Some curves are very abrupt. To cross the numerous streams and rivers it was necessary to build 134 culverts, drains, and bridges of 10 feet and less, and one hundred and seventy bridges of from 12 feet to 625 feet span. The track is a single one, but has four sidings. Work was commenced in January, 1850, and the last rail was laid on the night of January 28, 1855. The original contractors for the work were Messrs. G. M. Totten and J. C. Trautwine. Previous to entering into this contract, they were engaged in constructing the Dique Canal, to connect the Magdalena River with Carthagena. Soon after undertaking the work of constructing the railroad they were released from their contract at their own request, and retained as the engineers of the road, the company itself taking the responsibility of construction.

In regard to the mortality which occurred during the progress of the work, it is almost impossible to make any certain statement. No doubt the number of deaths was very great, and for that reason has been exaggerated. The president of the road in 1855 said, in relation to this matter, that "the first blow was struck in January, 1850. Since then a strict record has been kept of deaths which have occurred among the white men employed by the company, and up to the time

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of opening the road, on the 28th January, 1855, the number was 293, of which many are known to have been caused by diseases not incidental to the climate. How many white men were connected with the work during the period cannot be accurately detailed, but the number was at least 6,000. No record was kept of the mortality among other classes of laborers; but the proportion was greater among coolies, and less among Jamaica men and natives."

Although the number of recorded deaths is not very great, it must be remembered that few, if any, of the laborers who were employed escaped without contracting disease, and that many deaths of whites even remain unrecorded.

THE CHIRIQUI ROUTE.

This route lies in the State of Panama, between the Chiriqui Lagoon, on the Atlantic, and the Gulf of Dulce, on the Pacific. It is noticed, not because it claims any attention as a route for a ship-canal, but to show why it has no such claim.

In 1860 it was made a subject of study by a Commission directed by Congress "to examine into and report upon the quality and probable quantity of coal to be found there upon the lands of the Chiriqui Improvement Company; upon the character of the harbors of Chiriqui Lagoon and Golfito; upon the practicability of building a railroad across said Isthmus, so as to connect said harbors; and generally upon the value of the privileges contracted for in a conditional contract made on the twenty-first day of May, eighteen hundred and fifty-nine, between Isaac Toucey, the Secretary of the Navy of the United States, and Ambrose W. Thompson and the Chiriqui Improvement Company."

The members of the Commission were: Capt. F. Engle, U. S. N.; Lieut. W. N. Jeffers, U. S. N.; Lieut. J. St. C. Morton, of the Topographical Engineers, U. S. A.; and Dr. John Evans, geologist. The time and means at the disposal of the Commission were not sufficient to permit the execution of a full survey. An elaborate series of barometric observations, taken at the sea-level hourly during the absence of the exploring party, served as the standard for the reduction of all observations taken in the field.

The altitude of the most practicable pass for a railroad through the Cordillera, which is here made up of extinct volcanoes from 7,000 to 11,000 feet high, is 6,270 feet above the sea-level. In concluding his report to the Secretary of the Navy, Captain Engle states that "the results of the explorations and surveys made by the Chiriqui Commission are thus demonstrated: By Lieutenant Morton, that a practicable route for a line of railroad has been found between the two oceans, on the Isthmus of Chiriqui; by Lieutenant Jeffers, the hydrographer, that the great and grand harbors at its termini afford every requisite for the protection of naval and commercial marine, and, for all practical purposes, to an unlimited extent; and by Dr. Evans, the geologist, that the best coal for steam navigation exists at and near the Atlantic harbors of the Chiriqui Lagoon."

NICARAGUA.

Any valuable knowledge of the proper topography of this isthmus is of recent date; although doubtless its general features were early known to the Spaniards. Their leaders, Gonzales, D'Avila, and Hernandez de Cordova, partially explored it, when they named it Nicaragua, from the Cacique, so called, who aided them in its conquest. In 1854, D'Avila and Cerneda, commanding a squadron of discovery under Cortez, announced the existence of an interior fresh-water sea at only three leagues from the coast—a sea which they said rose and fell alternately, communicating, as was believed, with the North Sea. Various reconnaissances were made under the idea that, by this communication existing with the Gulf of Mexico, an easy transit could be established between the Spice Islands and Spain. It was even laid down on old maps that a communication by water existed from sea to sea. Other and later maps represented a river, under the name of Rio Partido, as giving one of its branches to the Pacific Ocean, and the other to Lake Nicaragua. The archives of Madrid contained French and English memoirs on joining the Pacific and the lake, based on these crude ideas—memoirs opened to Humboldt in the end of the eighteenth century. A knowledge of the country obtained by an exploration by the engineer Bantista Antonelli, under orders from Philip II, served to correct these false ideas. Surveys previously ordered by royal decrees in 1524

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and 1537 were never executed, "the Castilian captains of Nicaragua being fully occupied by their own rivalries and by their search for gold."

The report made at a later date, 1779, to Charles III of Spain, by Cramer, Ysasi, and Muestro, was unfavorable; they represented that in place of the supposed communication between the lake and the Pacific, high mountains intervened, and that the lowest part of the bottom of the lake was 43 feet higher than the level of the Pacific. Don Manuel Galisteo, in 1781, reported the same to be 55 feet lower than the Pacific, and the surface of the lake to be 35 feet higher. He made the distance from the Pacific to the lake 18.5 miles; the elevation of the summit 284 feet above the ocean and 151 feet above the lake, thus giving the height of the lake above the ocean 133 feet. A canal by this route, he reported, would require a tunnel, as open cuts exceeding 65 feet in depth were not ordinarily made.

This was an enterprise of greater magnitude than the commerce of that day would justify, but it was by no means beyond the skill of Spanish engineering talent bold enough to project and execute the great work of the Mexican Desague to secure the City of Mexico from the effects of floods. Humboldt refers to it as "one of the most gigantic hydraulic operations ever executed by man," and Admiral Fitzroy says: "This wonderful work, 200 feet deep and 300 feet wide for nearly 1,000 yards and above 100 feet deep through an extent of 3,000 yards (making altogether two miles of distance in which that vast excavation would be capable of concealing the masthead of a first rate man-of-war), executed within the last three centuries within Central America, should induce us to listen respectfully to the plans of modern engineers, however startling they may appear at first."

The successful acquirement of independence by the Central American States almost immediately prompted plans and memorials to them from English and American capitalists for constructing a canal. Companies were formed and negotiations entered into for this purpose, among which latter was a proposal by Minister Canaz to the United States Government, through Hon. Henry Clay, Secretary of State, in the year 1825, asking co-operation in constructing a canal. Mr. Clay instructed our representative, Mr. Williams, February 10, 1826, to ascertain if surveys had been made, if confidence could be placed in their accuracy, and what facilities of construction were offered. No detailed report appears ever to have been made, doubtless prevented by the unsettled political state of the country; no survey was furnished, none renewed.

In 1830, after the failure of the American house of Palmer, in connection with Barclay & Co., of England, to enter upon their concession from Central America, General Verveer, of Holland, visited Nicaragua for King William, who two years before had announced his intention of sending two engineers to make a survey for a canal. The perpetually recurring revolutions in Central America and the war between Belgium and the Netherlands prevented additions to a knowledge of the country.

The favorable disposition of General Morazan, President of Central America in 1836, toward a canal, induced him to employ on a survey Mr. John Bailey, R. M., long a resident in the country. His exploration, begun in 1837, was interrupted by the revolution which within ten years displaced Morazan. It was also confined to the Pacific side and the lakes.

In the month of August, 1850, under appointment from the American Atlantic and Pacific Ship Canal Company, Col. O. W. Childs, a distinguished engineer, accompanied by Messrs. J. D. Fay and S. H. Sweet as assistants, began a survey on the Pacific side. The instructions which he received favored his examination of the route from Salinas Bay, but, as he was not strictly bound to these, he made reconnaissance of other routes also, preferring finally that which terminates in Brito. His reconnaissance between the lake at the mouth of the Sapoa River and the Pacific at Salinas Bay gave these results: elevation of the summit, 534 feet above the bay; elevation of a summit which might be established by means of a low dam, 432 feet; depth of cut required, 119 feet; ascending lockage from the Lake, 320.5 feet; descending lockage to the Pacific, 432 feet; permanent supply of water from Sapoa River, 4,000 cubic feet per minute, and sites for reservoirs for additional supplies very favorable. The disadvantages of this line, are: depth of cut; length of distance necessary for deposit of excavated material; large amount of lockage; expense of water-supply, and a cut through rock for three-fourths of a mile from margin of the bay to deep water.

In regard to the route from the lake to Realejo, advocated by the late French Emperor, and for the construction of which a decree of the Congress of Central America had passed in 1846 and

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Napoleon had been invited to take charge, Colonel Childs reported: The canal between Lakes Nicaragua and Managua would be 20 miles long and would have to be constructed without any advantage from the Rio Tipitapa; an ascending lockage, from one lake to the other, of 28½ feet would be required; from Lake Managua, in the direction of the Pacific, the summit-level would occupy about 26 miles, upon which a depth of at least 55 feet of cutting would be required; the length of canal needed to open communication between Lake Nicaragua and the Pacific would be 46 miles, and it would involve an excess of 57 feet of lockage beyond that required in the plan of making Lake Nicaragua the summit-level of the canal.

Colonel Childs concluded, after examining the whole strip of land contiguous to the Pacific and Lake Nicaragua, "that the line leading from the mouth of the Rio Lajas to the Pacific at Brito presented more favorable conditions for the construction of a canal than any other." He made of this and of the whole eastern section a most careful and thorough survey. In this connection it is proper to state that the chief points of Childs' survey seem to be fully confirmed by the surveys as reported by Commander Lull, who says (while preferring to accept a line from Lake Nicaragua to the Pacific by the Rio Medio in place of the Rio Lajas),* "Childs' description was found to be correct in the main, and his route was ever after taken as a standard of comparison for all others." His survey was the first one ever made for the location of a ship-canal route on the American Isthmus that conformed to the requirements of engineering science.

Capt. Bedford Pim, Royal Navy, after several years' study of Nicaragua, developed a project for a railroad transit through this isthmus from Monkey Point, on the Atlantic, to Port Realejo, on the Pacific, "in the interests of peace and the commerce of the world, on the broad basis of free trade." The line included 180 miles of railway and 85 miles of lake navigation. The estimated cost was $3,000,000, and the time required in transit twenty-three hours.

By an article in the contract between Nicaragua and the Central American Transit Company, a survey of the harbor of San Juan del Norte (Greytown), and of the river San Juan, was made in 1865. The instructions of the company were that the engineer should "determine upon the practicability of permanently improving the San Juan River and of reclaiming the harbor of San Juan del Norte so as to admit ocean steamships into the latter and to allow steamboats of not less than four feet draught to navigate the former." On application to Hon. W. H. Seward, Secretary of State, by Don Louis Molina, minister from Nicaragua, and on reference of said application to the Secretary of the Treasury, Capt. P. C. F. West, of the Coast Survey, was permitted to undertake the work under appointment as chief engineer of Nicaragua. The examination which he made, and one made a year later by a committee appointed by the National Academy of Sciences, showed the causes of the deterioration of Greytown Harbor, and suggested the means for its partial restoration. The committee consisted of General A. A. Humphreys, U. S. A., Rear-Admiral C. H. Davis, U. S. N., and J. E. Hilgard, Acting Superintendent of the Coast Survey, They were assisted in their investigation by Mr. Henry M. Mitchell, United States Coast Survey.

TEHUANTEPEC.

The northwestern extremity of the American Isthmus takes its name from one of the small districts of the old Spanish Empire "Tecoantepec" or "Teguantepec." Its topography appears to have been for a long time unknown or to have been forgotten after having been learned by the Conquistadores. They certainly knew something of it. In 1520, in consequence of information given by Montezuma to Cortez, Diego Ordaz reconnoitered the Coatzacoalcos, and in the next year Sandoval explored this river and the Chimalapa. The western section, the ancient "Tehoantepec," was conquered by the first expedition sent by Cortez in this direction to explore the South Sea; and, although it was ascertained by the pilots that no strait existed connecting the two oceans, the route between the two river mouths continued to be regarded of great importance on account of the nearness of the two oceans, and because the river Coatzacoalcos afforded such facilities for transporting the materials for ship-building from Vera Cruz to the Pacific. The

* Preferred on account of greater security from surface drainage, but now rejected for the Lajas route since it has been ascertained that the flood waters of the Rio Grande can be avoided by diverting the river from the Pacific to the lake.

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materials for building Grijalva's fleet, sent in 1534 to conquer California, and for that in which Cortez himself set sail, for the same destination, in 1535, were thus brought from the Gulf of Mexico to Tehuantepec, a port still promising in the sixteenth century to hold the place since taken by Acapulco. The forests of Tarifa, midway on the Isthmus, themselves furnished ship timber for both coasts; they kept the dock-yards of Tehuantepec and Havannah supplied. The river Corte, the headwaters of the Coatzacoalcos, took its name from the cutting of ship timber on its banks.

From these circumstances the general topography of this isthmus must have been early known. But, for a time, it died with the conquerors. The death of Cortez, the establishment of Vera Cruz, the viceroys taking up their abode in the city of Mexico, and especially the strange pawnings of the Moluccas by the Spanish Emperor, and consequent temporary passing of their trade from the Spanish to the Portuguese, withdrew attention from the Isthmus. From the latter part of the sixteenth century Acapulco took the place of the open roadstead of Tehuantepec, and became the seat of commerce. The spirit of monopoly in Spain limited the trade to a single port in each sea, Acapulco and Vera Cruz. This isthmus ceased to be the trade route except in time of war.

The traditions of its topography soon became exaggerated and otherwise falsified. It was even pretended that it was almost a level plain; that in the rainy season the Indian bateaux could cross from sea to sea; that the Coatzacoalcos had its source near the Pacific; that as it approached the Cordillera the mountains were depressed; and that the Ostuta or Chimalapa rolled its waters equally into both oceans.

In 1771 the well-known discovery of bronze cannon in the castle of San Juan d'Ulloa, Vera Cruz, served at first to renew these false ideas, and then to destroy them. The question started itself, by what route the ordnance had come from Manila, where they had been cast? It could not have been by either Cape, no trade having thus been carried on between Vera Cruz and the Philippines; nor could they have come to the Gulf coast from Acapulco, climbing the Cordilleras of New Spain. The conclusions, verified by records and traditions, gave them to the Tehuantepec route.

The Viceroy, Don Antonio Bucarelli, therefore ordered two engineers, Don Antonio Cramer, governor of San Juan d'Ulloa, and Don Miguel Corral, to examine again the topography of the Isthmus, to ascertain whether any natural communication existed by interlocked river branches, and at the same time to report upon the practicability of locating a canal. Their exploration was very imperfect. No elevations were determined, but they reported that the Coatzacoalcos did not rise near the Pacific; that the evenness of the ground plainly indicates that it would not be a work of great difficulty to effect a communication between the seas, and that a canal could be built with neither locks nor inclined planes.

The topography of the Isthmus was again examined at the close of that century by order of the Viceroy Revillagigedo, the successor of Bucarelli, who desired the construction of a small canal for batteaux between the Chimalapa and the Alaman, a tributary of the Sarabia. His death prevented the prosecution of the work.

Soon after Mexico had acquired her independence, the Government charged General Juan Orbegozo to explore the route. This able officer made a careful instrumental examination and reported that the canalization of the Isthmus of Tehuantepec "was problematical and gigantic," and that the roadstead of Tehuantepec was being more and more abandoned daily by the ocean.

A yet more elaborate survey was executed in 1842–'43 by a Commission appointed by the projector, Don José de Garay, who had received a liberal concession from the Mexican Government, under Santa Anna. The chief officers of the Commission were: Don Gaetano Moro, an Italian engineer, who had long been a resident in Mexico; Lieutenant-Colonel Trouphliniere, Captain Gonzalez, and Don Manuel Robles, professor at the Military College, Mexico. They employed instruments of precision, but some of them appear to have been injured before beginning their work. They reported the route as favorable for the location of a canal for small steamers, or of a railroad, either of which was permitted by the grant. The height of the summit at Tarifa Pass was determined to be 684 feet, and they reported that the difference in level between the beds of the Chicapa and the Ostuta is so inconsiderable that there is no doubt of the possibility of a junction of these rivers, and there is no obstacle in the short intervening distance to prevent it. They proposed to feed the summit level of the canal by a feeder line from these two rivers. The length of the canal

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proper was estimated at 50 miles, and the length of the feeder 15 miles. The elevation of the summit was to be overcome by the use of one hundred and sixty-one locks, and the cost of the canal it was estimated would be less than $17,000,000.

By two decrees successively, Santa Anna extended the time for the commencement of work under Garay's concession, and Salas, in 1846, further extended it to 1848. In 1846–'47 Garay assigned his concession to Messrs. Manning & McIntosh, of England, who again assigned the claim to Mr. P. A. Hargous and others forming the Tehuantepec Railroad Company. This company, in 1850, received passports from the Mexican Government for their engineers, the United States minister, Mr. Letcher, having advised Mexico that "the company desired to make a thorough resurvey," as full confidence was not reposed in that made in 1842. Hence the survey by Williams, 1851–'52, for General Barnard, arrested, however, by Mexico, June 3, 1851.

Mr. Williams is the first to recognize officially the three natural main divisions of this Isthmus. The first of these, distinct in its general characteristics, embraces the part from the Gulf of Mexico to the Cordilleras' base; the second embraces the mountainous districts in the center; the third, the level country bordering the Pacific. The first, the Atlantic plains; the second, the mountain region; the third, the Pacific plains. The first is from 40 to 50 miles in breadth, made of alluvial basins, and draining the northern slope of the Cordilleras. The second belt is from Jaltepec River on the north to within 25 miles of the Pacific, a belt about 40 miles wide. The third division, from the base of the mountains to the Pacific, has an inclination of from 10 to 15 feet per mile.

The chief points in the reported "reconnaissances," as Mr. Williams styles his interrupted work, are:

I. That Coatzacoalcos is the chief hydrographic basin.

II. That with few exceptions the entire country embraced in the northern division presents the appearance of a broad plain, densely covered with forests.

III. The chain of the American Cordillera traverses the middle division from east to west, but, instead of the lofty volcanic peaks elsewhere found, there is a sudden depression of the range in its passage across the Isthmus, at a point directly in the line of shortest communication between the two oceans. The table-lands in this section comprise an area of about 1,400 square miles. By a narrow opening, or gap, in the mountains which on the south bound the plains of Xochiopa, Chivela, and Tarifa—mountains of 1,500 to 2,000 feet above the Pacific—the descent is suddenly made from the elevated table-lands to the Pacific plains.

IV. These plains generally present a remarkably smooth, even surface, with a uniform gentle slope towards the sea. Of the eight rivers which drain this slope, seven empty into the lagoons connected with the sea by a narrow outlet called Boca Barra; the eighth, the Tehuantepec, empties directly into the sea at La Ventosa.

V. The most important of these streams, as regards length and volume, are the Ostuta, Chicapa, and Tehuantepec. The fact that they always rise and fall simultaneously has originated the belief in their having a common source. "The true reason is, no doubt, to be found in the fact that they proceed from the highest points in the Sierra, and through the upper part of their course are in close proximity."

VI. The lagoons extend nearly 40 miles along the southern coast, and comprise an area of more than 200 square miles; they are generally shallow.

VII. The Bay of La Ventosa is only partially sheltered.

VIII. The mouth of the Coatzacoalcos is 115 miles west from the river Tobasco and 110 from Vera Cruz. Its width is about 1,500 feet. The depth of either pass on the bar diminishes to 11 or 12 feet in the month of May. Seven miles from the Gulf the lead shows a depth of 40 feet. The least depth below Minatitlan is 12 feet. "The soundings made on the bar at the mouth of the river give about the same with those given by Cortez in 1520; the material of the bar, therefore, not appearing to change its position, gives promise of permanency in any work designed for improving the depth."

The survey which has been now referred to had for its object "to establish an available route for the great flood of travel between the Atlantic and Pacific coasts." It was for a railroad. No observations were made specially directed to the practicability of a canal. Instead of passing over Moro's Summit, Tarifa, the passes of Chivela and Masahua were surveyed. In 1857 the railway

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project was resumed under a new survey executed by W. H. Sidell; and at the present time a railway transit across Tehuantepec is actually supported.

In regard to the Isthmus of Honduras it is proper to state that a knowledge of its physical features has been gained from the surveys instituted by the British Honduras Interoceanic Railway Company. Its excellent harbors—Puerto Caballos, on the Atlantic, and La Union, on the Pacific—and its internal features offer many attractions as a route for railway transit, but it possesses no merit as a route for canal communication.

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CHAPTER X.

UNITED STATES ISTHMIAN EXPEDITIONS—THE WORK BEFORE THEM AND THE SPECIAL FITNESS OF THE NAVY TO PERFORM IT—THEIR ORGANIZATION—METHODS OF EXECUTING THE SURVEYS—OBSTACLES ENCOUNTERED—INCIDENTS ATTENDING EXPLORATIONS IN THE ISTHMUS—THE WORK ACCOMPLISHED.

It will be remembered that Admiral Davis declared Darien to be almost a "*terra incognita*," and, further, "that there did not exist in the libraries of the world the means of determining even approximately the most practicable route for a ship-canal across the Isthmus." In the light of what has been presented regarding the early explorations on the Isthmus, the force of this statement can be readily appreciated.

To deliver the problem from the chaotic state in which it had been placed, and remove a blot from the record of the nineteenth century, was the work before the United States Isthmian Expeditions. To effect this, exact and systematic methods replaced those of speculation; a process of elimination weeded out the routes possessing no merit and left for the inspection of the world those that were worthy of comparison.

Although the early explorers generally failed to furnish satisfactory results, their labors were not in vain, as many lessons were to be gained by studying the causes of their failures. These studies developed a proper appreciation of the difficulties attending these explorations, and it became clear that to obtain satisfactory results it was not only necessary to use instruments of precision, but that the party using them must be well organized and backed by a substantial commissary department. Provisions in small, water-tight packages suitable for transportation in a wilderness, an abundance of shoes, clothing, and medical stores, a well-organized provisioning party, and a party of native macheteros to cut through the forest, were essential to success.

The selection of the Navy to perform this work must be regarded as wise and economical. Here was a single organization which had in itself all the resources for such work. The immediate object was to secure reliable data upon which the engineer could base his calculations and make his comparisons. By education and familiarity with instruments of precision, the naval officer was competent to do this, and the general handiness and adaptability of the sailor, qualities constantly called into requisition, fitted him specially for the work. Beyond the collection of instrumental data, there was a field for the employment of the expert talent which was furnished by the scientific staff assisting in the surveys.

To insure the best results a harmonized party was necessary. Without discipline and a military spirit, this harmony can rarely be attained in a work involving such extraordinary demands upon the physical and mental resources. The climate and the many annoyances of the country tend to produce a mental weariness and irritation which have generally proved destructive to the harmony of all parties unschooled in the art of performing a duty for duty's sake. The records of the expeditions show with what zeal, energy, and ability the surveys were executed amidst hardship and exposure of a painful character; and it is a fact of which the United States can feel proud that the work could not have been more ably performed.

As already stated, Admiral Ammen, the active spirit in developing the project of systematic exploration, was made the Chief of the Bureau of Navigation, Navy Department, where, under the authority of the Secretary of the Navy, he superintended all the important features and many details of the organization of the several Isthmian expeditions, and directed their efforts, as far as possible, during the surveys.

The Darien Expedition, the first to enter the field, was placed under the command of Commander T. O. Selfridge, U. S. N. Guided by general instructions and notified of the resources placed at his disposal, the duty of organizing the field parties, directing their work, maintaining them in the field, and of overcoming almost insurmountable obstacles, was left to him. The resources of the expedition were abundant, both in *personnel* and material, but an economical

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Map of the Caledonia route, showing localities examine l by U. S. Darien Expedition of 1870.

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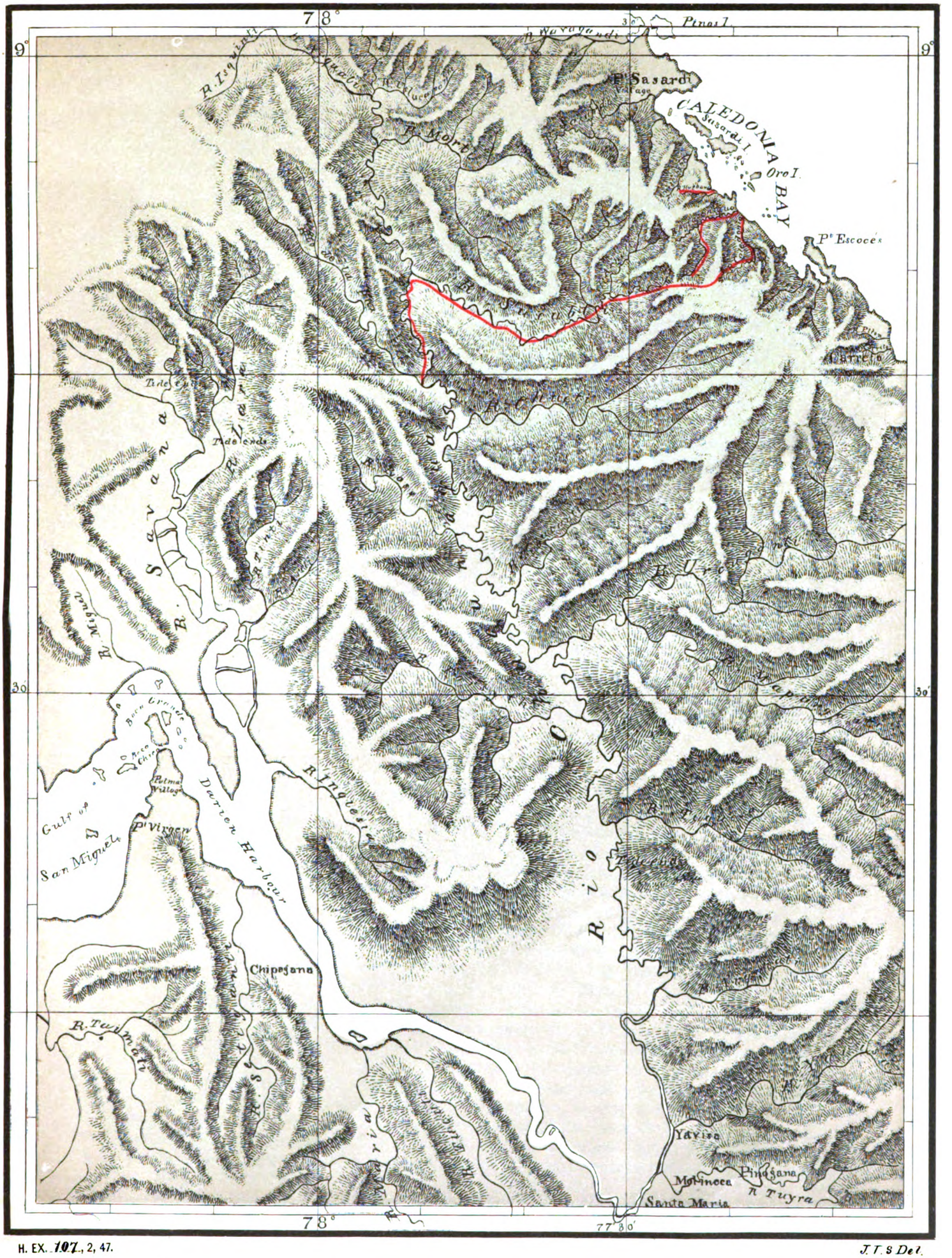

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and successful employment of them called forth qualities of a high order which were found in the judgment, zeal, wonderful energy, and executive ability of Commander Selfridge.

The work of the Darien expeditions extended over a period of five years, from 1870 to 1875, and as the object of the expeditions was to clear away all doubts respecting this Isthmus and its vicinity, all the routes were examined, excepting the Truando and Atrato–San Juan, and their practicability or impracticability authoritatively established.

From one to three vessels of war were employed during the surveys, as necessity required; the officers and men entering upon the field duties. The resources of the first two expeditions, those of 1870 and 1871, were further increased by an able scientific staff. The instrumental outfit was complete for astronomical, topographical, and hydrographical work.

The general plan pursued in the examination of a route was to make a barometrical reconnaissance first, and, if the result justified it, a level and transit line was run to develop a correct profile. In most cases this line followed the bed of a stream as far as possible, in order to avoid the necessity of cutting a wide trail through the forest for the instrumental line. If the resulting profile was unfavorable, it was then known that a better one did not exist in that basin, and consequently the route was eliminated. If, on the contrary, the profile thus obtained appeared favorable, the route merited further study, and a level and transit survey for actual location was made. Of all the valleys examined during the Darien expeditions, that of the Napipi was the only one meriting this second study.

All the results obtained by the expeditions were gained in the face of innumerable obstacles arising from the character of the country, its climate, and its pests. In a preceding chapter enough has been written to give an idea of the disagreeable environment of an explorer on the Isthmus, but when the exigencies of the service requiring severe manual and mental labor are added, it can be inferred that his lot is not a happy one. The absence of roads of any kind and the impassable nature of the country made it a very difficult matter to forward supplies to the parties in the field, as all provisions had to be carried by natives employed for the purpose, and in some cases the journey to a party in the field would involve a period of five days. These circumstances made it necessary to reduce the number in each working party to a minimum, and each officer and man became the bearer not only of his personal effects, but each had his share of camp equipage, provisions, and instrumental outfit to labor under on the march and on camp moving days. To lighten the load as much as possible, therefore, became a great object; and with this view the personal effects were reduced to what was absolutely essential, and only two suits of woolen undergarments were carried. One suit being nearly always wet, the other was carefully guarded, and, if possible, kept dry to sleep in. In the morning, sooner than run the risk of having two wet suits, the dry one would be removed, carefully stowed away in the knapsack, and the cold, wet suit, after a preparatory wringing out, reluctantly adjusted to the shivering body. No matter whether at work in the hills or in the swamps or on the open river, there are hardships all around. To follow a trail avoiding rivers is to suffer thirst; to follow one crossing streams is to pass, while overheated, into the cool waters of the river; if in the swamps, freedom is circumscribed for days by the limits of a small flat-boat; and if on the open river pursuing a canoe journey, sitting tailor-fashion on the bottom of the canoe in an inch or more water, for hours, may at least be regarded as monotonous. When to this list is added the general result, fever, it will be readily conceded that Darien placed a heavy tax upon those who struggled to learn her secrets.

While a detailed description of the operations of the Isthmian expeditions would be interesting, it would be difficult to include such an account within the limits of a single chapter, and, moreover, it is rendered unnecessary by the existence of elaborate reports made by the officers commanding the different expeditions. The present purpose will be to point to the localities that have been examined, to state the results of such examinations, and to show the character and sufficiency of the information upon which a final comparison of practicable routes depends.

The Darien expedition of 1870, operating from the Atlantic coast, examined the Caledonia, Morti, and San Blas routes. Notwithstanding the unfavorable reports of Strain and Gisborne respecting the Caledonia route, Dr. Cullen persisted in stating his belief that a pass such as he had described really existed. This persistency left a doubt in the public mind as to the sufficiency of information relating to this route, and it was therefore necessary to make such explorations and

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surveys as would forever settle the question. As might be expected, the results proved the impracticability of the route for the purposes of a ship-canal.

The valleys of the Aglaseniqua, Washington, and Aglatamati Rivers, emptying into Caledonia Bay, were subjected to instrumental examination; a barometrical reconnaissance was made over the dividing ridge to the Sucubti, thence by this river to the Chucunaqua, and down the latter river to its junction with the Tupuganti; and, finally, a line of levels was run from the valley of the Aglaseniqua across the divide to the headwaters of the Sucubti. The divide was found to vary in height from 1,000 to 1,500 feet, and when the level line struck the Sucubti its elevation was 553 feet. Referring to this height, Captain Selfridge says it "dissipates all idea of a pass; for, were there such, this river would flow to the Atlantic instead of the Pacific; and pricks the bubble of Dr. Cullen's Darien route, with its highest elevation of 200 feet." To overcome the elevation on this route by a system of lockage would be impossible, as the water supply for the summit-level is altogether inadequate, and to seek a lower summit-level by tunneling would involve a tunnel eleven miles long.

A line of levels carried through the valley of the Sassadi and over the divide to the Morti River developed a profile quite as unfavorable as that of the Caledonia route. The divide was found to be 1,148 feet high, and the elevation of the Morti, where the level-line met it, 289 feet. Estimating from the elevation of the mouth of the Sucubti, which is stated to be not less than 140 feet, the mouth of the Morti is placed at an elevation of at least 160 feet. Tunneling would therefore have to commence near this point and be carried for a distance of nine miles to the point of tunneling on the Atlantic slope. This fact alone is sufficient to condemn the route. These surveys eliminated the routes in the vicinity of Caledonia Bay. It was unnecessary that the lines should be run across the Isthmus, as the unfavorable conditions developed by the surveys, as far as they were carried, were sufficient to show the impracticability of the routes for the purposes of canalization.

Although the rainy season had commenced, it was considered desirable to secure such a knowledge of the San Blas route as would either condemn it or lead to a further survey the next year. It will be remembered that the engineers who surveyed this route for Mr. Kelley, in 1864, carried their level line from the Pacific to a point on the Atlantic slope which was estimated to be two or three miles from the Gulf of San Blas; and that at this point the survey had to be abandoned on account of the appearance of hostile Indians. They reported the route feasible with a tunnel seven miles long. The fact that the line was incomplete, rendered it necessary that the deficiency should be supplied. Extraordinary efforts were therefore made, but the difficulty of forwarding the surveys became daily greater and greater on account of the heavy rains and floods. "At one time," says Captain Selfridge, "I felt great apprehension lest I should be obliged to relinquish the survey. Our provisions were about exhausted, our crews worn out by the fatigue incident to the work, and no longer kept up by the charm of novelty; the macheteros, upon whom came the task of carrying provisions, were discontented at being kept out beyond their agreement, and the rains threatened to burst upon us at any moment, rendering the return of the parties from the field both difficult and dangerous. Our stock of shoes, of which we had used up some six hundred pairs, was so low that it was difficult to equip a dozen men. At the same time, could we carry our levels over the divide, we should be able to decide upon the practicability of this route, without requiring a return, and have the satisfaction of knowing that we had accomplished the task that we had set out to do." This they succeeded in doing.

The level and transit line followed the Mandinga River to the Samgandi, and the latter river to the foot of the divide, where it had an elevation of 377 feet. From this point a south-southeasterly course was followed and the dividing ridge crossed at an elevation of 1,142 feet. The line then followed the Butler River, on the Pacific slope, to the Mamoni, and this latter river to its junction with the San José, a point on the line surveyed by Mr. Kelley's engineers. The levels carried to within a mile of the junction ended with an elevation of 690 feet. Captain Selfridge states that "the junction of these two rivers differed from Mr. Kelley's only half a mile, serving as an excellent verification of the correctness of this gentleman's engineers, for our line started from a point established by astronomical observations, while the other party had the Pacific shore line for a basis, which is doubtless half a mile in error."

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Maps "S" and "K" are from tracings from the map of the San Blas route, accompanying the report of Captain Selfridge, and from that prepared by Mr. Kelley's engineers, with additional delineation.

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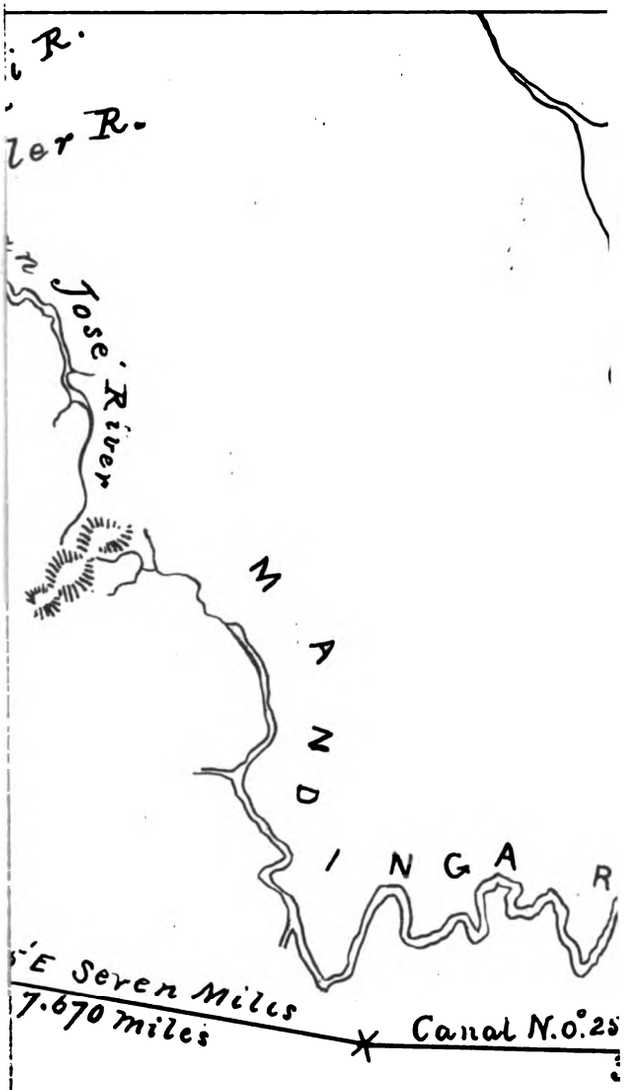

9000 feet to one inch.

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While the main line of survey was advancing, a survey was made in the valley of the Nercalagua to its headwaters. In summing up the results of the work on this route Captain Selfridge says: "Our survey connecting with Mr. Kelley's gives us a line of spirit-levels from the Atlantic to the Pacific which, following water courses that cut the Isthmus transversely, produce the lowest possible profile. * * * Upon looking at the profile, there will be found between the elevations of 190 feet, this quantity including 30 feet as the depth of the canal, a distance of at least 10 miles. A tunnel of such length, and of the dimensions required for a ship-canal, is out of the question as regards cost, if not without the limit of engineering skill; and though this line is but 27 miles in length, with a most capacious harbor, still, from its mountainous features, I am compelled to pronounce it equally impracticable with the routes previously surveyed in the vicinity of Caledonia Bay."

The unfavorable character of this report caused disappointment to those who looked hopefully to San Blas as the probable route for interoceanic communication; and the fact that neither survey in itself was complete from ocean to ocean, left some doubts in the public mind as to the sufficiency of the information relating to this route. The two surveys seemed to be in conflict; on the one hand, a tunnel seven miles long would be required, and on the other hand the tunnel would have to be at least ten miles long. Mr. Kelley's engineers stoutly defended the accuracy of their work, and there was no reason to doubt the accuracy of the work performed by the Government expedition. There seemed to be no other way to settle the matter than by a new survey, but in view of the following attempt to reconcile the differences, this may be regarded as unnecessary.

A STUDY OF THE SAN BLAS SURVEYS.

Owing to well-known causes, neither Kelley's survey nor Selfridge's furnished, by itself, a complete line from ocean to ocean. A combination of the two surveys produced results which have been disputed.

From the partial survey made by Kelley's engineers a line was laid down between the mouths of the *Mandinga* and Bayano Rivers. Its length is given as 27.5 miles. Seven miles of this distance is involved in a tunnel.

From the combined surveys Selfridge finds the line between the mouth of the *Mandinga* and ship navigation on the Bayano 27 miles long. To the mouth of the Bayano it is 33¼ miles. The tunnel involved is 10 miles long. The difference in length of these two lines is nearly 4 miles, and 3 miles of this difference apply to the tunnel.

A careful study will tend to show that these statements are not as conflicting as they seem to be. This study will be based upon the data taken from Selfridge's map No. 12, and from that prepared by Mr. Kelley's engineers contained in Admiral Davis's report. These will be referred to as Map S and Map K.

An inspection of Map K shows that Kelley's engineers followed the Bayano to the Mamoni, the Mamoni to the San José, and this last river to the divide. Crossing the summit they struck the headwaters of the *Mandinga*, which they followed down to within an estimated distance of 2 or 3 miles from the Atlantic.

An inspection of Map S shows that Selfridge worked up the *Mandinga* to the Samgandi; up this river to a small tributary by which the line was carried to the divide. Crossing the summit, the line follows the Butler River to its junction with the Mamoni, and then proceeds down this river to its junction with San José, where both lines connect. A portion of the *Mandinga* River is involved in both lines, but in name only, as will appear. The *Mandinga* River on Map K has its mouth located almost due *south* from Point San Blas. The mouth of the *Mandinga* on Map S bears about *southwest* from Point San Blas, and is 7 miles west from the *Carti* River, which corresponds to the *Mandinga* on Map K.

There is reason to believe that much of the confusion which attends the subject of the San Blas route is due to the application of the same name to two different rivers. For instance, in writing or speaking thus: "Kelley's level and transit line followed down the Mandinga and Selfridge's followed it up"; it would appear that the Atlantic portion of both lines were coincident; but such is not the case. No portion of Kelley's line on the Atlantic slope comes near Selfridge's level and

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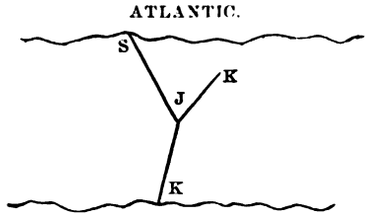
transit line, but it is coincident with a line of barometrical reconnaissance executed during the second Darien expedition.

The two lines are represented in the following diagram; the stem of the Y and its right branch representing Kelley's line; the left branch Selfridge's; J is the junction:



A glance will show that the lines K J and S J, treating of different localities, are quite sure to have different characteristics, and the stories they tell will be in conflict if they are both supposed to treat of the same section of country.

Regarding the lines as they exist, what are the results furnished?

Each line is entitled to speak authoritatively as far as it goes only.

Kelley's survey gives all the elements of a section from the Pacific to a point on the Atlantic slope, which was estimated to be 2 or 3 miles from the coast line. Not having reached the Atlantic, it bears no evidence to the width of the Isthmus.

Selfridge's survey, commencing on the Atlantic, gives all the elements of a section to the point of junction. From this point to the Pacific, Kelley's line speaks authoritatively, and the line resulting from a combination of the two is as complete as if one party had surveyed it.

From the plan and section revealed by the combined surveys on this line S J K it will appear that the least length of the canal, from ocean to ocean, is 32.43 miles, and that 10.68 miles of this distance will require tunneling.

Selfridge's work was not confined to this one line, however, as he determined the features of the Nercalagua Valley. Connecting the elevation of 190 feet, determined by this survey of the Nercalagua, with Kelley's point of tunneling on the Pacific, the result is a tunnel 9.37 miles long, the length of canal, from ocean to ocean, being 30.97 miles. Selfridge's work, therefore, in connection with Kelley's, practically establishes *two* lines from ocean to ocean. To these two a *third* is to be added. It is also the result of a combination, but in this case *all* of Kelley's line is included, which, it will be remembered, terminated within an estimated distance of two or three miles from the Atlantic. Selfridge's astronomical and hydrographic work in the Gulf of San Blas, together with a barometrical reconnaissance up the Carti River, makes it possible to replace the estimate by actual data. From the Atlantic end of the tunnel to the shore the shortest distance on Map K is given as 3.87 miles; on Map S it is 7 miles. This difference of more than three miles cannot be disputed, as it is established by the astronomical determination of the Atlantic coast line.

An inspection will now be made of the proposed line of canal as laid down on Map K. Its principal divisions are clearly shown, and their lengths are also given, but they do not correspond with actual measurements taken from the map. The following table shows the differences which exist:

	Figures.	Actual.	Greater or less by—
	Miles.	*Miles.*	*Miles.*
Atlantic shore to tunnel	3.873	3.693	−.180
Tunnel	7.000	7.670	+.670
Pacific end of tunnel to Paneis	8.996	8.550	−.446
Paneis to tide-lock	1.314	1.250	−.064
Tide-lock to mouth of Bayano	6.400	6.619	+.219
Total miles	27.583	27.782	+.889
	.....	27.583	−.690
Difference	.....	0.199	+.199

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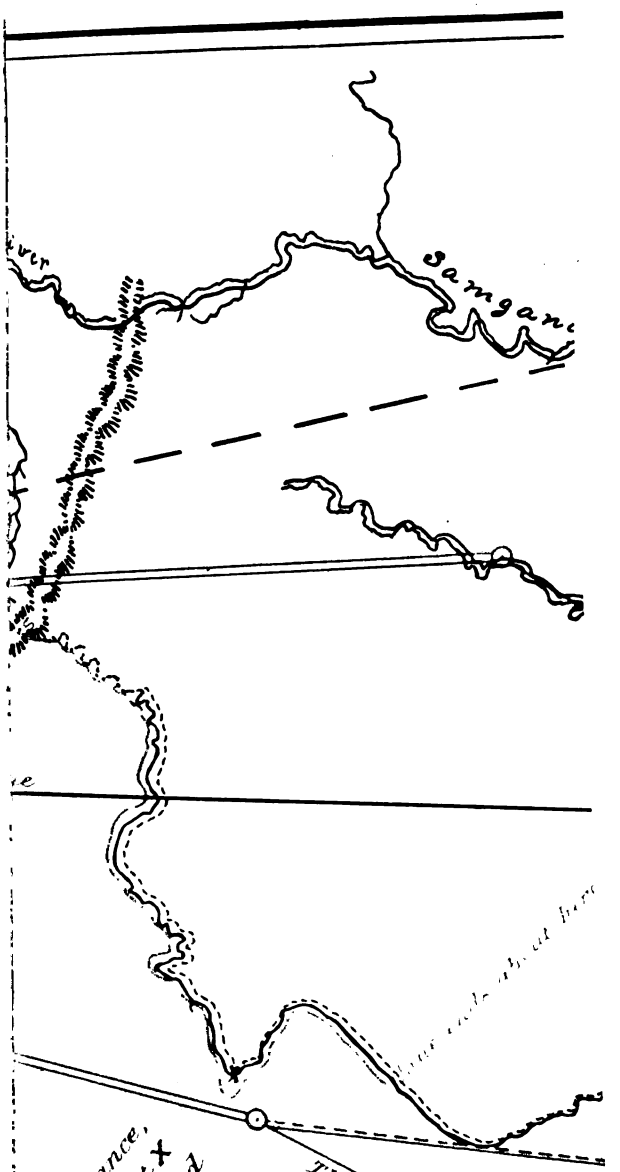

ad distance,
ver, this point
wing bearings and

ge N. 65° E., 4.6 miles.

The mouth of the San José
where the two lines connect is
distant, in an air line, from t
mouth of the Bayano, on
Selfridge's Map 103,304 feet
Kelley's do. 101,400 " =
Diff. 1904 " =

This difference being in a direction n
length of the tunnel, accounts for the
ridge's Map over that shown on Keelle

Length of tunnel, Selfridge's Map 8.
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It will appear from the above that while the length of the line as given and that obtained by measurement differ but little, the lengths of its sections differ considerably. This is particularly the case with the tunnel, which shows an excess in length of .67 of a mile or 3,537 feet.

This line, which will be called the Carti-Mamoni, is plotted on Map S, and the means of determining the termini of the tunnel are explained thereon. The length of the line and each of its sections are given below, together with those taken by actual measurement from Map K:

Carti-Mamoni.	Map K.	Map S.	Greater or less by—
	Miles.	*Miles.*	*Miles.*
Atlantic shore to tunnel	3.693	7.000	+3.307
Tunnel	7.670	8.050	+ .380
Pacific end of tunnel to Pancis	8.550	8.680	+ .130
Pancis to tide-lock	1.250	1.368	+ .118
Tide-lock to mouth of Bayano	6.619	6.250	— .369
Total miles	27.782	31.348	+3.935
		27.782	— .369
Difference		3.566	+3.566

The greater part of this difference applies to the Atlantic slope, or to the unfinished portion of Kelley's line, and for reasons already given cannot be disputed. The length of the tunnel is not much greater than that taken from Map K, and this excess can be accounted for when it is understood that Selfridge found that the two surveys differed about a half a mile in locating the mouth of the San José.

By taking the bearings and distance of the mouth of this river from the mouth of the Bayano, it will be found that the distance on Map S is 103,304 feet, and on Map K 101,400 feet; the difference is 1,904 feet, or .36 of a mile. This difference being in a direction which affects the length of the tunnel, accounts for the excess on Map S over that on Map K.

	Miles.
Length of tunnel, Map S	8.05
Length of tunnel, Map K	7.67
Difference	0.38

AIR-LINE.

Distance across San Blas.	Map K.	Map S.
Mouth of Bayano to Atlantic	25.960	30.050
		25.960
Difference		4.090
Head of Pacific tide to Atlantic	15.454	19.525
		15.454
Difference		4.071

These differences are almost identical, and on that account tend to show that, except in the width of the Isthmus, the two maps are relatively correct.

CONCLUSION.

The principal points of dispute connected with the San Blas route were in regard to length of tunnel, width of the Isthmus, and length of line. The statements are as follows:

	Map K.	Map S.
Width of Isthmus	25.960	30.050
Length of line	27.583	30.975 and 33.250
Length of tunnel	7.000	9.375 and 10.680

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If these statements applied to the same line there certainly would exist a wide difference of opinion, but as it has been shown that they apply to different localities they do not conflict with each other.

There can be no conflict unless the two surveys can claim different results for similar points. In all the work on San Blas there is but one point which is common to both surveys, and that is at the mouth of the San José River where both lines meet, but the very difference between the two locations of this point, a half a mile, tends to prove the general accuracy of both lines.

This study shows that the combined surveys furnish the elements for three lines across San Blas. On the Pacific slope they may be regarded as having a common stem to the point of tunneling, from which they diverge to different points on the Atlantic coast.

These lines and their principal features are given below:

	Length of line.	Tunnel.
Mandinga-Mamoni-Banayo	33.250	10.68
Nercalagua-Mamoni-Bayano	30.975	9.375
Carti-Mamoni-Bayano	31.348	8.050

The point of tunneling on the Atlantic slope of the Carti-Mamoni is determined by Kelley's survey. In view of the comparative shortness of the tunnel by this route, it is well to point out a feature which bears testimony to the correctness of this determination; it is that all three points of tunneling on the Atlantic slope are situated at nearly the same distance from the divide.

DARIEN EXPEDITION OF 1871.

The existence of suitable harbors determines, in the first instance, the points from which exploration should be made. As the operations of the previous year included all the routes leading from harbors on the north coast of Darien, the exploration of this section was finished. The next harbor to attract attention is that into which the Atrato River empties in the Gulf of Darien, or Uraba. This, certainly the finest harbor on the coast, and suitable in all respects for the grand purpose of interoceanic communication, was selected as the locality from which explorations of the southern portion of Darien and the valley of the Atrato were to be made.

The operations of this year were carried on during a period of six months, including all of the dry and a portion of the rainy season. The organization of the expedition was substantially the same as that of the previous year, but it was considered unnecessary to include the marine escort, as the Indians of the Atrato Valley were not as likely to interfere with the working parties as were the "Bravos" of Darien. The vessels employed were the United States ships Guard and Nipsic on the Atlantic coast, and the Resaca on the Pacific. Owing to the extent of country to be explored, it was necessary to commence work from both sides of the Isthmus. After a preliminary reconnaissance of the interior, Captain Selfridge planned the work to be undertaken by the parties working from the Atlantic, and proceeded by way of Aspinwall to the Pacific, where he remained to direct the efforts from that side. This arrangement was made possible, as the Atlantic division was placed under the command of Capt. E. P. Lull, U. S. N., an experienced and active worker in the first surveys, who, although entitled to be relieved from the command of the Guard on account of recent promotion, volunteered to remain with the expedition.

From the Atlantic the main line of survey was carried up the Atrato to the Cacarica, and from this river to the Peranchita, which it followed to the divide. From the Pacific the line followed the Tuyra to the Cué, and this river to the divide, where connection was made between the work of the Atlantic and Pacific parties. The result of the survey was to prove the utter impracticability of the route; its harbors were the only good features it possessed. The divide at the point where the survey crossed was over 800 feet high, and the Pacific slope was a net-work of hills, ranging in height from 200 to 400 feet. The length of the actual canal from the mouth of the Cacarica to a point 5 miles below Santa Maria, on the Tuyra, would be 55 miles; and its cost,

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Atrato-Perauchita-Tuyra route.

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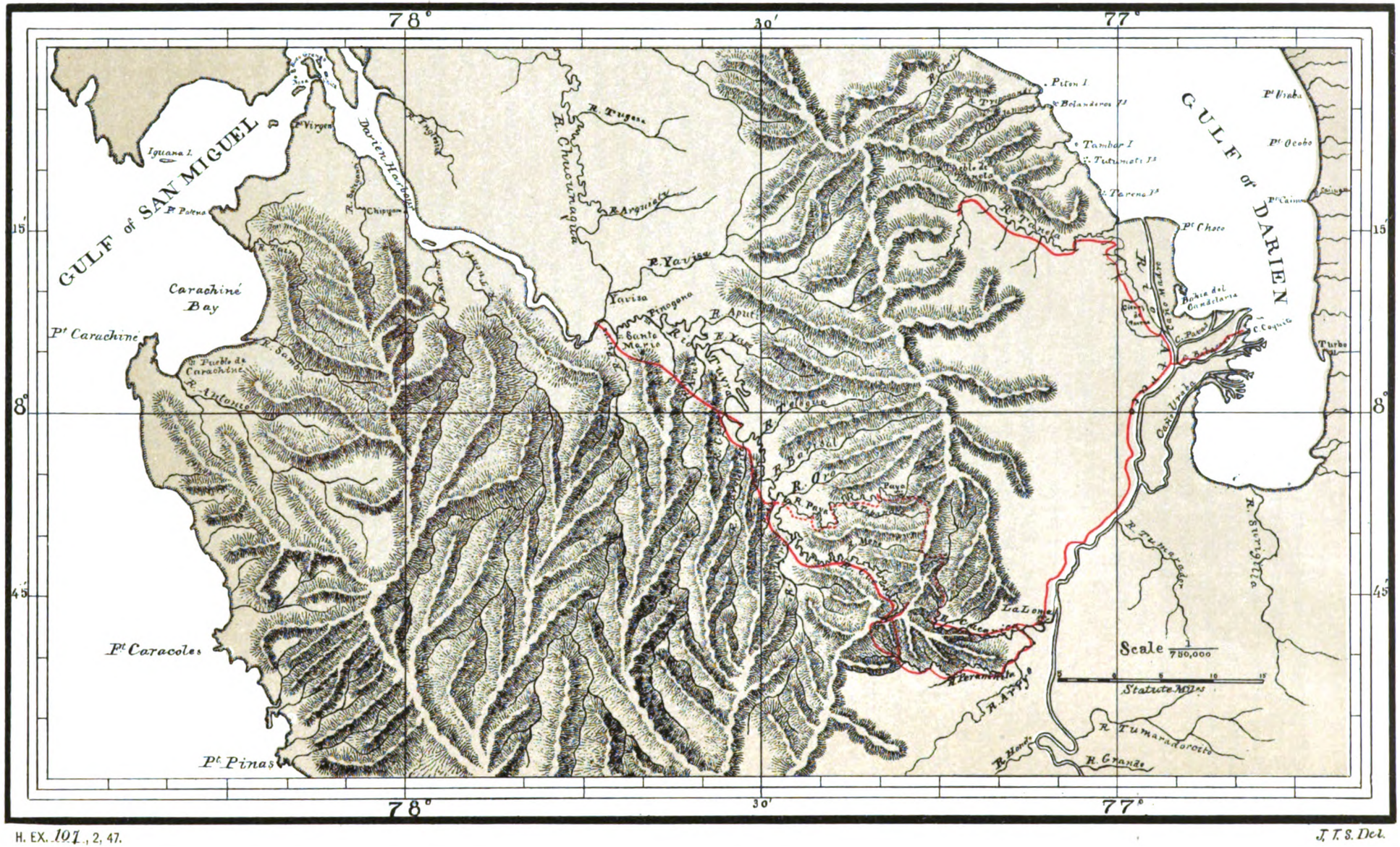

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based upon a system of lockage with a summit level of 160 feet, would exceed two hundred and fifty millions of dollars.

The results of this survey settled the projects of Gogorza and De Lacharme, and a reconnaissance up the Tanela River, proved the inaccuracy of De Puydt's statements. At a point four or five miles from the headwaters of the Tanela, in a direct line, a height was obtained by barometrical measurement of 638 feet; so the divide must be much higher even, and very far away from the elevation of 150 feet given it by De Puydt.

While these surveys were in progress, a party was dispatched to Limon Bay, on the Pacific, to run a line of levels from that place over the divide to the headwaters of the Napipi and down the bed of that river to the Atrato. This work was successfully accomplished and the resulting profile showed that this route merited closer study, but owing to the lateness of the season it was impossible to continue the work longer.

As the profile of the Napipi route showed the necessity of tunneling for five miles through the Cordilleras, it was deemed advisable to develop another route in its vicinity which, it was hoped, would involve a shorter tunnel. With this view a third expedition was organized. The line selected for development commenced at Chiri-Chiri Bay, on the Pacific, crossed the divide, and entered the Tucundo, which river it followed to the Cuia, and the latter river to the Bojaya, which carried it to the Atrato. The survey proved that the valleys of the above rivers were not as well adapted for the location of a canal as that of the Napipi. When this fact was ascertained, attention was directed to the Doguado, a tributary of the Napipi, whose headwaters were in close proximity to the line of survey from Chiri-Chiri Bay. A survey of the Doguado was therefore made to the Napipi with the gratifying result of a better profile than had yet been obtained, and from which it appeared that the tunnel would be about three miles long. The appearance of the valley of the Napipi added largely to the hopes held forth by the profile; hardly any hills were to be seen until near the main Cordilleras; the banks of the river were generally low, and seemed to extend back for some distance without any rise. The total length of the canal from the Atrato to Chiri-Chiri Bay would be only 28 miles. With the data at hand, Captain Selfridge planned and estimated for a lock canal by this route, which was to cost about $61,000,000.

With so much in favor of the route, a survey for actual location was determined upon, and, at the request of Captain Selfridge, Lieut. Frederick Collins, U. S. N., was assigned to the duty of fully developing this line. This work was performed during the dry season of 1875, and the results, although not as satisfactory as were hoped for, proved the practicability of constructing a canal 30 miles long, with a tunnel of 3½ miles, at a cost of about $98,000,000.

In the case of the valley of the Napipi, as in every other case where appearances were at all relied upon, disappointment resulted. It was a frequent experience of the officers engaged on this survey, veterans in Isthmian work, in the face of every evidence to the contrary, to encounter hills of considerable height in places where they expected to have a good level stretch of field-work. The height of the trees, the density of the forest, and the limited range of anything like horizontal vision, prevent hills from being seen from the river.

With this survey the work of the Darien expeditions ended. The results obtained, in connection with those secured by Mr. Kelley, relieved all doubt respecting this portion of the American Isthmus, and presented the Napipi, the Truando, and the San Blas routes as its most practicable routes for interoceanic communication.

TEHUANTEPEC EXPEDITION.

Although the Tehuantepec route had been subjected to several instrumental examinations, they were mainly directed to ascertain the practicability of establishing a railway transit, and while the question of a suitable water-supply for a line of canalization received some attention, it was not satisfactorily determined. It was therefore necessary to remove all doubts in this connection, and to this end an expedition was organized and placed under the command of Capt. R. W. Shufeldt, U. S. N., in the fall of 1870. In a memorandum setting forth the object of the expedition and the plan of operations to be followed, Captain Shufeldt says:

"With the advantages of modern science a canal can be built anywhere, involving only the question of expense, provided water can be found to fill it. This is the problem which the expedi-

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tion must solve, and for this purpose a thorough exploration must be made at the summit level Tarifa, said to be 680 feet above the sea, so far has been considered the lowest elevation, and Señor Moro, in 1843, devised a system of feeders from the adjacent rivers by which water could be brought to that point sufficient for the purpose. It will be the object of the present party to verify his report, and also to ascertain if any additional source of supply can be obtained.

"If water cannot be obtained, either by natural or artificial means, at that point, or some lower level found, then any further work will be useless so far as this expedition is concerned. But, getting a satisfactory solution to this problem, then I suggest a survey of the lagoons on the Pacific side, and an examination of the outlet of the lagoons into the ocean, with a view of determining their character as a harbor.

"On the Gulf I propose a survey of the bar of the Coatzacoalcos, to estimate the possibility of deepening it. That being found unadvisable, then to examine the adjacent point, 'La Barilla,' with a view to forming an artificial harbor for the entrance of the canal. This work being accomplished, I propose to follow the probable line of the canal between these ports, to form some estimate of the character of the soil, the natural obstacles, and the liability to inundation during the rainy season. We do not propose to define the character of the work to be constructed or to estimate its cost. An undertaking of such magnitude should not be commenced until every foot of the way has been thoroughly examined, and every possible contingency calculated."

In accordance with these considerations, an examination was first made of the plan proposed by Señor Moro for feeding the summit-level of a canal at Tarifa Pass by the junction of the Ostuta and Chicapa Rivers. It was found that the joint delivery of these rivers was not sufficient to feed a canal, and, moreover, that it would be impossible to effect a junction between them as the Ostuta lies 180 feet below the summit. An examination of all the streams in the vicinity of Tarifa and Chivela passes was then made, and it was found that their aggregate delivery was insignificant, and, in addition, that most of them did not possess the necessary elevation at suitable points even if their delivery was ample for the purpose needed.

While this examination was in progress, several level and transit lines were run to ascertain the elevation of the different passes through the Cordilleras, with the hope of finding a lower summit than that of Tarifa. The results showed that Tarifa was the lowest and most available, therefore the route for the canal became limited to that pass.

The problem to supply the summit-level with water still remained unsolved, and attention was turned to the Rio Corte, or Upper Coatzacoalcos, as the only river likely to fulfill the required conditions. It was found that the Corte could supply a sufficient amount of water at a suitable elevation to feed a canal having a wet suction 22 feet deep, 60 feet wide at the bottom, and 162 feet wide at the surface.

A level and transit line was completed between Salina Cruz, on the Pacific, to the junction of the Blanco and Corte Rivers, but with the limited force in the field it was not found possible to continue the line to the Atlantic. From the previous surveys for railway purposes, it was assumed that the route of the canal would be from the head of ship navigation in the Coatzacoalcos, near the island of Tacamichapa, thence by the valley of that river to the summit at Tarifa; descending the Pacific slope by the valley of the Chicapa to the harbor of Salina Cruz. The length of the canal by this route would be 144 miles and the number of locks required one hundred and forty. To utilize the water supply of the Corte, a feeder-line 27 miles long will have to be constructed. With reference to a canal by this route, Captain Shufeldt concluded that it "can only be deemed practicable to the extent of its political and commercial necessity, measured by the progress of the age."

NICARAGUAN EXPEDITION.

The determination of the most practicable route for interoceanic communication through Nicaragua was greatly facilitated by a knowledge of the general character of the country, and particularly by the special information furnished through the survey made by Col. O. W. Childs. For the important duty of testing the correctness of this survey and of extending the inquiries so as to include the whole territory lying in the region of available routes Commander A. F. Crosman, U. S. N., was selected. The expedition was organized and sailed from Key West on board of the United States steamer Kansas, Commander Chester Hatfield commanding, and arrived off

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Greytown, Nicaragua, on April 7, 1872. Here, at the threshold of the scene of its labors, a sad accident deprived the expedition of its capable and gifted commander. On the 12th April, while passing through the surf on the bar off Harbor Head, in the vicinity of Greytown, the steering oar of the whale-boat broke, the boat broached to and capsized. Commander Crosman retained his self-possession and command of the party, and, when the boat drifted upon the bar where a footing could be obtained, he had the boat righted and put head to sea, but in spite of every effort she was repeatedly overturned and the officers and men washed away from her. On the last occasion the boat drifted from the bar into deep water with Midshipman Stevens and four men clinging to her. Commander Crosman endeavored to swim to a small spit of land near by, but a strong current carried him into the breakers, when he was seen to sink in the surf. The remaining officers and men of the whale-boat were rescued, but Master Alfred Foree and four seamen of the first cutter's crew were drowned in attempting the rescue.

The command of the expedition now devolved upon Commander Hatfield. He proceeded with the surveying parties to Lake Nicaragua and commenced operations on the west side of the lake, but owing to the lateness of the season he was unable to carry the work to completion. He succeeded, however, in securing valuable information respecting the Sapoa, Lajas, Buena Vista, and Ochomoga routes, between the lake and the Pacific.

On the Sapoa route, the most southerly of the transverse valleys across the Cordilleras, a level and compass line was carried from the lake to the summit, which was found to have an elevation of about 900 feet above the lake. This elevation, together with the unfavorable aspects of the remainder of the route, which was examined without instruments, caused its abandonment as impracticable. The Lajas route was surveyed from the lake to the harbor of Brito, and the results were in close agreement with those obtained by Colonel Childs. The total length of the line is 18.52 miles, and the highest elevation of the natural surface of the ground was found to be 49.28 feet above the level of the lake as it stood on May 2, 1872. The height of mean high lake above high water at Brito was determined to be 103.14 feet.

In surveying the line just described, frequent reconnaissances were made with the object of finding another line by which the route would be shortened and the valley of the Rio Grande avoided. From the knowledge gained in these reconnaissances it was deemed advisable to survey from a point about half-way between the lake and the Pacific, on the Lajas line, to the divide and thence to the lake by the Rio del Medio. It was not possible to complete this work, but the survey was carried far enough to give results which pointed to the possibility of locating a line having better conditions for surface drainage than the valley of the Rio Grande afforded, and which would at the same time be shorter than the line previously located by the Lajas route, but the cut through the dividing ridge would have to be much deeper.

A level and compass survey commencing at the Rio del Medio line, near the summit, was carried in a northerly direction for 5 or 6 miles to a depression called Buena Vista, which was found to have an altitude of 186 feet above the lake. The survey was then carried down the valley of the Chacalapa to a point near its junction with the Tola, when further work was prevented by heavy rains. The distance from the lake to Brito by this route is about 20 miles. The survey of the Ochomoga was carried to a point about 8 miles from the lake, when the surveying party was recalled. The bed of the stream at the point where the line ended was found to be 79 feet above the lake. The banks of the river were 33 feet higher.

The parties were recalled on the 10th of June, and all work discontinued except the survey of the lake, for which purpose Commander Hatfield detailed Midshipmen J. D. Keeler, E. M. Hughes, and Francis Winslow, with four seamen, to remain and execute this duty during the rainy season.

EXPEDITION OF 1872–'73.

In November, 1872, the expedition was reorganized under the command of Capt. E. P. Lull, U. S. N., and proceeded to Nicaragua, where work was resumed during the latter part of December, and carried forward to completion.

The clearness with which Captain Lull states the conditions of the problem and its solution, with reference to Nicaragua, makes it desirable to quote largely from that portion of his report which relates to this subject. He says:

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"A glance at the map will show that any project for a canal through Nicaragua must involve the lake of the same name, not only because its water is needed at the summit-level, but because it occupies the narrowest part of the country. The problem, then, to be solved is the finding of the most accessible line of communication from the lake to the Pacific on one side and to the Caribbean on the other. The coast line on either side, and the shore line of the lake, were long ago laid down, the former with great and the latter with a passable degree of accuracy.

"The river San Juan, forming the only outlet of the lake, leaves it at the southeast extremity, at which point the lake shore approaches most nearly to the Caribbean. It is quite clear that there is between the lake and the Caribbean a line of communication, and that it is not only the shortest, but the lowest line, for if any other were lower, or as low, there would then be another outlet. How good a line, both in an engineering and a commercial point of view, this will prove to be, is the only question to be solved on that side of the lake. This information, however, would be of no practical value unless it was also found that a practicable line could be located between the lake and the Pacific. The first efforts of any explorer would therefore naturally be turned to that side of the lake.

"A narrow strip of land divides the lake from the Pacific, and our examination of the map shows that from Virgin Bay, on the lake, to San Juan del Sur, the distance is but 12 miles. Were our knowledge of the country confined to the coast and shore lines above mentioned, the route between these two points would naturally be the first examined, and the results obtained would thereafter be used as a standard of comparison until some other line was found, the sum of whose conditions gave a better general result. The conditions to be sought are:

"1. The shortest distance.

"2. The lowest profile.

"3. The most favorable profile.

"To explain what is meant by this last, that profile is most favorable, other things being equal, whose summit is nearest the lake, as it enables us to locate our locks to the greatest advantage, which advantage is often twofold: first, we are saved the necessity of crowding the locks together, which sometimes is, and sometimes is not, disadvantageous; and, second and principally, we are enabled so to locate the locks with reference to the surface as to diminish very much the amount of excavation required.

"A fourth consideration is that the line shall debouch at a point where a sufficient harbor either exists or can be made to protect the mouth of the canal from the sea. There are two other very important considerations to be kept in sight, one of which is the number of streams which intersect the line, the other the existence, or non-existence of accessible locations for the deposit of materials excavated. Of course, in comparing different routes, the points have to be considered together, as it often happens that a route superior in one respect is inferior in another. * * *

"Fortunately a great deal was known in advance in regard to the western division of the work. The country had been more or less explored, and at least one line had been reported as extremely favorable, *i. e.*, that from the mouth of the Rio Lajas to Brito, surveyed by Col. O. W. Childs in 1851. In accordance with the instructions of the Department, this line was the first examined by the expedition of last year, under Commander Hatfield. The report of Colonel Childs was found to be correct in the main, and his route was afterwards taken as the standard of comparison for all others."

For the reasons mentioned, Captain Lull directed the first efforts of the expedition to a definite determination of the best route from the lake to the Pacific. Commencing with the most southerly, the routes claiming attention are as follows:

1. From the mouth of Sapoa River to the Bay of Salinas.
2. From La Virgen to San Juan del Sur by the transit road.
3. By the rivers Lajas, Guscoyal, and Grande, to Brito.
4. By the Rio del Medio and Rio Grande to Brito.
5. By the pass of Buena Vista, the rivers Chacalapa, Tola, and Rio Grande, to Brito.
6. The valley of the Gil Gonzales.
7. The valley of the Ochomoga.

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Map of a portion of Nicaragua, showing line of actual location for a ship-canal, and the routes that have been surveyed.

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8. From the northwestern extremity of Lake Managua across the valley of Leon to the Bay of Fonseca, the port of Realejo or some other port on the Pacific.

As the Sapoa and Buena Vista routes were eliminated by the surveys of the previous year, it was unnecessary to investigate them any further. The remaining routes were examined and the following results obtained:

By the valley of the Gil Gonzales the most favorable pass has an altitude of 430 feet above the lake, and the length of the route via the Gil Gonzales, Chacalapa, Tola, and Rio Grande valleys to Brito would be about twenty-four miles.

On the Ochomoga route the summit is located 16 miles from the lake and has an altitude of 225 feet. The length of the line, carried on the Pacific slope in the valley of the Tobillo to that of the San Ygnacio and by the latter to the Bay of Albina, would be about 30 miles.

The Managua route, indicated by Louis Napoleon, involves the navigation of Lake Nicaragua to the Rio Tipitapa, by which it ascends to Lake Managua, which it leaves at its northwestern extremity, as stated above. The main object seems to have been to secure the port of Realejo for the Pacific terminus. The examination which was made of this route proved its inferiority. Mr. Menocal states that "the enormous amount of dredging required in both lakes and in the estero to obtain the requisite depth of 26 feet, the increase of 45 feet of lockage necessary to overcome the difference of level between the two lakes, amounting to 22.50 feet, and the uncertainty as to the possibility of keeping Lake Managua at the elevation required, owing to its limited watershed and the changes its elevation has undergone during a recent period, particularly if we take into consideration the porous nature and the consequent absorbing power of the volcanic formation of the valley of Leon, together with the difficulties to be overcome in canalizing the estero from Pasquiel to Lake Managua, and the formidable amount of cutting, with an extreme depth of 119 feet above the water, from this lake to the Pacific, a distance of about 22 miles by the shortest line to Tamarindita, and 42 miles to Realejo, were sufficient considerations to discontinue any further operations in this direction and abandon the line as impracticable, at least when compared with the more favorable one surveyed in the department of Rivas."

The route from Virgin Bay to San Juan del Sur is shorter than any other between the lake and the Pacific. It was hoped that this feature and a good port might compensate for the disadvantage of a high summit, but an examination showed that while the route would be only 14.5 miles long, the elevation of the summit is 605 feet above the Pacific, and borders it so closely as to render the location of locks on the steep slope a very difficult matter.

The elimination of all these routes limited the field of exploration to the locality of the Lajas and Rio del Medio routes. From a point about midway between the lake and the Pacific these routes coincide, so that the field meriting study was still further reduced to the watersheds of the rivers Lajas and Del Medio, on the lake slope. During the surveys of the previous year enough had been learned to indicate that the Rio del Medio route would present better conditions for surface drainage, and as the route was very promising, the surveying parties were directed to execute their work with great care and detail. Between the point of junction mentioned above and the lake, the two lines of survey offer the following results for comparison. On the Lajas route provision would have to be made for the waters of the Guscoyal, Espinal, Rio Grande, and eight smaller streams, while only two small ones, the Del Medio and Chacolata, are to be provided for on the Del Medio route.

In the matter of length the Del Medio route is the shorter by 1.49 miles, but the elevation of its summit is 90 feet greater than that of the Lajas. This difference in the summit elevations would make the cost of a canal by the Medio route much greater than by the Lajas route; nevertheless, as it presented more favorable conditions for the permanency of the work, it was adopted as the best suited for the location of a canal.

In 1880, the Secretary of the Navy directed Civil Engineer A. G. Menocal, U. S. N., who had assisted in both the Nicaraguan expeditions, to make a further study of this locality, in order to ascertain the practicability of diverting the Rio Grande to the lake and thus remove the only objection to the Lajas route. His studies met with very gratifying results as will be seen by his report, which is given in connection with the technical discussion of the Nicaragua route in Chapter XIII.

The best route between the lake and the Pacific having been determined, the whole force

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of the expedition was applied to the survey of San Juan. In order to have a complete line of levels from ocean to ocean, and to ascertain the width, depth, and course of the San Juan, a complete survey was made of this river from the lake to Greytown. This line of levels was carried through a distance of 119 miles by the river, and when compared with the line on the Pacific side, "showed the elevation of the lake to be absolutely the same above mean tide of either sea. When the character of the ground passed over is considered, this coincidence seems quite remarkable, and shows with what extreme care the work was executed."*

While this work was in progress, a survey was made along that portion of the valley of the San Juan where the canal would have to be independent of the river. From an inspection of the Upper San Juan it was found that between the lake and Castillo rapids the river could be improved to meet the requirements of ship navigation. It was, therefore, decided to commence the survey for the location of the canal along the left bank of the river from Castillo rapids. This work was successfully accomplished, and it is very gratifying to know that it was executed with great fullness and accuracy of detail. The direction of the survey was determined by reconnaissances ahead of the line, the character of the excavations determined by borings, and actual locations determined upon for such hydraulic works as would be necessary in overcoming the elevation of the summit.

"It was neither the design of the Department," says Captain Lull, "nor was it within the limits of possibility, to make, with the means and time available, particularly with the very small appropriation, an exhaustive final survey. I feel safe in asserting, however, that the country has been so far examined that a close approximation to the best line has been found. The line as laid down on the maps and the computations herewith presented are the result of actual survey. Nothing has been taken for granted, while, on account of the great promise of the lines at the outset, the surveys have been made much more in detail than would have been the case if they had been considered mere preliminary reconnaissances. So, that, while it is altogether probable that the line may be improved upon in many places, it can never be found to be any less favorable than it is here represented."

On all these isthmian expeditions much valuable information was secured by the scientific staff; and, in addition to the development of the topography of the different routes, astronomical determinations were made of initial points and hydrographic surveys were executed of all the terminal ports.

PANAMA EXPEDITION.

Upon the request of the Interoceanic Canal Commission for more specific information in relation to the Isthmus of Panama, the Secretary of the Navy directed that a close instrumental examination should be made of the route in the vicinity of the railroad. Capt. E. P. Lull, who was charged with the execution of this duty, was assisted by Mr. Menocal and several of the officers who had participated in the Nicaragua surveys. He was also directed to make an examination of the Bayano River, on the San Blas route, as it was suggested that the route might be found practicable "if the near approach of massive solid ground on both sides of the Chepo should make it possible by dams to flood considerable areas and distances for slackwater navigation." The results of these examinations are given in the technical discussion of these routes. As it was deemed impracticable to make a thorough cut from tide-water to tide-water, on the Panama route, the survey was directed to secure a line of location for a lock canal. This work was executed during the winter of 1875, and the results showed that a lock canal by this route was practicable, and its cost was estimated at $94,511,360.

This expedition completed the series of explorations undertaken by the United States, which furnish data covering the whole Isthmus as far as it is applicable to ship-canal purposes. While the character and sufficiency of the information thus obtained of any particular route are not questioned, there is often a lingering doubt as to its sufficiency concerning the whole Isthmus. What reason is there for believing that a better route than any examined may not have been overlooked? The answer is in the system followed in making the surveys. Referring again to the

* Report of Captain E. P. Lull, U. S. N.

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axiomatic statement that the bed of a river furnishes the line of lowest levels in the basin drained, it will be evident that if the profile determined by these levels is unfavorable, the whole territory drained by such river is eliminated from the field of study. If the profile is favorable it justifies an instrumental examination of the valley for an approximate location of the canal line. When all the rivers which merit investigation have received it, the result is the same, as far as it relates to the location of a canal, as if every square mile of the Isthmus had been surveyed. The United States Isthmian expeditions have executed this work, and their results, in connection with some others furnished through individual efforts, fully satisfy the question as to the character and sufficiency of information to name the only practicable routes, to make a final comparison of them, and to decide which is relatively the best.

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CHAPTER XI.

THE WYSE SURVEYS AND THE PARIS CONFERENCE.

THE WYSE SURVEY OF 1876 AND 1877.

On the 6th of October, 1876, Lieut. L. B. Wyse, of the French Navy, was authorized by a society calling itself the "Société Internationale du Canal Interocéanique" to proceed to Central America for the purpose of exploration.

The "Société" was a speculative company, of which General Turr was the president. The "Internationale" part of their title was derived from the fact that the United States of Columbia had been induced to name two "delegates."

Lieutenant Wyse was instructed to examine first the route from the Gulf of Urabá (Darien) to the Gulf of San Miguel, by way of the Atrato, Cacarica, and Paya Rivers. This route is the one proposed by Señor Gogorza. In case of the difficulties presented by this line being insurmountable, he was then to explore any route that seemed feasible "to the south and east of the line joining Capes Tiburon and Garachiné." These instructions were submitted to and approved by M. de Lesseps.

It may be remarked that the territory north and west of the line joining Capes Tiburon and Garachiné was included in the grant to the Panama Railroad Company, and the right of way through it would have to be purchased. Noticing this, it is plain that M. Wyse was not instructed to seek the *best line*, but the best line in a certain territory where the "Société" could secure a concession and profit by its sale.

The expedition was composed of Lieutenant Wyse, commander; Lieutenant Réclus, Captain Bixio, M. Celler, Ingénieur en chef des Ponts et Chaussées; Messrs. W. Brookes, B. Gerster, J. Millat, V. Barbiez, G. Musso, N. Boudoin, and L. De Lacharme, engineers; Dr. C. Viguier, naturalist; Messrs. E. Genty, L. Charlot, C. de Merendol, P. Pouydesseau, J. Lenoan, and D. Giocanti, assistants; Messrs. T. Carranza and M. Recuero, guides and interpreters. Messrs. P. Sosa and A. Balfour, engineers, were delegated by the Columbian Government.

It must not be supposed from the naval and military titles of some of its members that the expedition was in any sense a Government one; it was a private speculative enterprise, pure and simple.

In consequence of the nearness of Panama, and the "violent winds" which prevail on the Atlantic coast during winter, the explorations were begun on the Pacific coast about the middle of December, 1876, and terminated in the first part of April, 1877, a period of not more than four months, during which time no part of the expedition penetrated as far as the Atlantic coast.

This circumstance seems to have made no difference, as two canals were proposed and skillfully elaborated in their minutest details. In the one proposed by Lieutenant Wyse himself, he estimates the cost within ten per cent., although that half of the route which included a tunnel and the heaviest cutting was not subjected to even a preliminary reconnaissance.

In view of the above facts it is unnecessary to describe the route proposed by Lieutenant Wyse further than to show its peculiar features.

PROJECT VIA THE TUYRA, THE CAQUIRRI, AND THEIR AFFLUENTS.

This route was explored under the supervision of M. Celler, and was conducted with instruments of precision as far as the "Palisades of the Caquirri," and reconnoitered as far as the "Loma of Cacarica."

The lowest elevations found were in the pass of Tihulé, varying from 69.02 to 138.68 meters above low-water mark at Pinagana. The other routes examined showed elevations from 145.9 to 167.3 meters above low-water. The lines examined by M. Celler were:

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No. 1, via the Tihulé and the Nabluquia.
No. 2, via the Cué, the Puquia and the Tulégua.
No. 3, via the Aquiagua and the Tulégua.
No. 4, via the Uignati and the Aquiagua.

After a critical examination, M. Celler states that an interoceanic canal through the pass of the Cordilleras, without locks and without tunnels, is impossible. On the other hand, either by route No. 1, with a tunnel from the mouth of the Pachulé to the mouth of the Nabluquia, or by route No. 2, with a tunnel from the junction of the Puquia to the forks of the Tulégua, and by using cuts of 80 to 85 meters deep at the extremities of the tunnels, tide-level canals could be constructed. This, M. Celler says, presents in itself nothing that is impracticable, but owing to the river valleys being so sinuous as to be useless for canalization, thus necessitating deep cuts for 35 or 40 kilometers, an expenditure would be required which would render the canal financially impossible. He also condemns any scheme attempting to utilize the rivers by means of dams and locks on account of the extreme sinuosity of the valleys and the "variable supply of water."

A tide-level canal being out of the question, he proposes the following scheme of a lock canal, for which, he frankly says, they made no special surveys, as they were confined by their instructions to the consideration of a tide-level canal.

SCHEME OF A LOCK CANAL PROPOSED BY M. CELLER.

Starting from the Pacific the canal follows the Tuyra, deepening and rectifying its channel for 63 or 64 kilometers to Pirri or the Real de Sta. Maria. Thence it follows the shortest route past Pinagana and the river Cupé, and, finally, raises itself to the plateau of the Upper Tuyra; crosses from the left to the right bank of the Tuyra, between the Pucro and the Paca; crosses the Paya; follows the valleys of the Cué and the Puquia; tunnels through the divide, and descends by the valleys of the Tulegua and the Cacarica to the Atrato, and thence down the Atrato to the Atlantic. Total length of route (as given by Lieutenant Wyse) 230 kilometers, of which 95 to 100 kilometers will have to be canalized. The summit-level will be 48 or 50 meters above low tide of the Pacific. Five locks are proposed on each side of the summit. Length of tunnel, 700 meters, with cuts 80 meters deep at its extremities and cuts of 30 meters extending for 9 kilometers.

To insure the water supply, dams 30 or 40 meters high would be constructed across the Paya, the Punusa, and the Pucro Rivers, making reservoirs which would store up some millions of cubic meters. Ordinarily the Tuyra and the Cacarica would join in supplying the summit-level.

A prominent feature of this scheme consists in making the section of the canal on the plateau of such size that the speed of vessels shall not be limited.

SCHEME OF A TIDE-LEVEL CANAL VIA THE VALLEYS OF THE TUPISA, TIATI, AND ACANTI-TOLO RIVERS.

This route was explored under the personal supervision of Lieutenant Wyse as far as its junction with the Tiati, about one-half of the distance which it is proposed to canalize. The remainder was not even reconnoitered. The route is divided into six sections, commencing on the Pacific.

Section No. 1 follows the Tuyra which is to be made navigable as far as the Island of Piriaque.

Section No. 2 is the beginning of the canal proper, and extends in a straight line, nearly due east, to the Chucunaque River, which enters the canal through a grillage or grating, built for the purpose of arresting the *débris* brought down by the freshets. This *débris*, M. Wyse says, will have to be removed from time to time "in the beginning," but will become unnecessary as the work progresses, for the timber to be used in construction will be cut on the banks of the Chucunaque and floated down. Exactly why it will become unnecessary to remove the *débris* is not apparent. If it is not removed a dam will be formed, and the river will either rise and burst through, or, what is more probable, cut for itself a new channel around the grillage. Natural dams or log jams of from 20 to 30 feet high are not uncommon in this country. In regard to the mud and sand brought down by this river, M. Wyse says it is not necessary to think of it, as the alternating tidal action will clean the canal most thoroughly.

The third section, commencing at this point, follows the Tupisa "simply digging out and

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rectifying its sinuous course" for 11.4 kilometers. The numerous affluents are received into the canal through grillages, first being lowered to its level by means of cesspools or pockets.

The fourth section follows a course of N. 57° E., and intersects the Tiati after having gone about 10 kilometers.

At this point the exploration ended, and the expedition returned to Europe.

Most explorers and engineers would have been unable with the data obtained up to this point to actually locate and estimate the cost of the entire canal. M. Wyse, however, by constructing a chart, which was a scientific mean between the old Spanish charts, which placed the Atlantic coast five marine miles too far to the west, and the later and exact charts, was able by using his own consummate knowlege of the ordinary topography of the country to continue the location to the Atlantic. By this means section 4 was continued 7 kilometers in a straight line, making its length 17 kilometers.

The fifth or tunnel section has cuts of 55 or 65 meters at its extremities. The dimensions of the tunnel are: Height from bottom of the canal (here 10 meters deep), 36 meters; breadth at bottom, 16 meters; at surface, 20 meters; length, determined from M. Wyse's corrected chart, 14 kilometers. The whole correction of 4.5 kilometers is subtracted from the tunnel.

The sixth section extends from the end of the tunnel, 12 kilometers, to the Atlantic at the mouth of the Tolo, through cuts of an average depth of 25 meters.

M. Wyse introduces in this canal a peculiar feature which does credit alike to his ingenuity and to his desire to economize. To overcome the effect of the Pacific tides, and to reduce the amount of excavation, he proposes that the bottoms of sections 2, 3, and 4 have a rise of 75 millimeters per kilometer "in such a manner that the tidal wave shall have nearly spent itself at the entrance of the tunnel." The total rise of the bottom of the canal so effected is about 3.3 meters. The mean rise and fall of the tide is about 5.2 meters.

The dimensions of the canal are: Breadth at bottom, 25 meters; at surface at low tide, 50 meters; at surface at high tide, 60 meters; depth at low tide, 8.5 meters. Estimated cost of the whole work, from ocean to ocean, including tunnel, breakwaters, light-houses, and incidentals, plus 10 per cent., which M. Wyse states is sufficient for all unforeseen expenses, 594,000,000 francs.

THE WYSE SURVEYS OF 1877 AND 1878.

On the 21st of October M. Wyse was authorized by the "committee of direction of the Société Internationale du Canal Interocéanique" to return to Central America to complete the surveys of the Tupisa, Acanti-Tolo, and Atrato-Tuyra routes begun in 1876. In case these routes should not respond to the hopes of the committee, he was to make the investigations and researches necessary for the definite location of a small number of routes susceptible of practical execution. Associated with him were Messrs. Réclus, Sosa, De Lacharme, Verbrugghe, and Pouydesseau. M. Wyse was especially charged with the negotiations with the Columbian Government regarding the concession. M. Réclus, in the absence of M. Wyse, was in charge of the surveys. These surveys were undertaken for the expressed purpose of maturing plans to be submitted to and approved by an International Conference or Jury, the scheme of whose organization had then been determined upon.

On the 6th of December, 1877, the party under M. Wyse commenced a survey of the San Blas route. He went up the Bayano and Mamoni, intending to connect at the junction of the San José River with the last stake of the American expedition of 1870, under Commander Selfridge. On the 12th M. Wyse left M. Réclus in charge and returned to Chepo. The work continued until the 15th, when, having reached a point a short distance above the Fall of Chararé, they were compelled to stop, not being able to obtain canoes and not being prepared to cut a trail.

Upon the return of the party, M. Wyse being very anxious to connect with the American survey of 1870, returned to the Falls of Chararé with M. Verbrugghe, and, by dint of much wading, managed to reach the desired point. In the mean time M. Réclus ran a line for 5 or 6 kilometers up the Rio Terrable, starting from its junction with the Bayano. On account of the nature of the country, although the elevation was slight in the ravine, M. Réclus decided that the route was impracticable and returned to Capitana.

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On the 29th of December the expedition left Panama for Darien, arriving at Yavisa on the 3d of January, 1878. On the 8th they commenced the ascent of the Tiati, and on the 11th Messrs. Wyse and Verbrugghe returned to Panama, and thence to Colon, where they took passage upon the Dupetit-Thouars, a French man-of-war, for Acanti. Arriving at Acanti, they made a reconnaissance of the Acanti River as far as its confluence with the Guati, of the Aquiti, the Tolo and its tributary, the Neca, whilst the officers of the Dupetit-Thouars made an astronomical determination of the position of the village, and a hydrographic survey of the roadstead of Acanti. This determination showed that M. Wyse in constructing his chart of 1876–'77 had placed the coast line at the very least 2.25 marine miles too far to the west. Messrs. Wyse and Verbrugghe then proceeded to Bogota.

In the mean time the expedition under M. Réclus had commenced work, and on January 14, 1878, connected with stake "1,091 *bis*," the last stake of the survey of 1876–'77. On the 19th they left the Tiati and took a trail which they followed across the divide into the valley of the Tupisa. They then followed the Tupisa.

On the 6th of February they separated, M. Réclus intending to reach the Pacific and rejoin M. Wyse on board the Dupetit-Thouars; M. Sosa was to return to Yavisa with the greater part of the expedition, and M. De Lacharme to establish the location of the double locks which he proposed for the Atrato-Tuyra route.

At this point the survey may be said to have ended. M. Réclus, with a few men, ascended to the headwaters of the Tupisa, crossed the divide and descended to the Atlantic at Acanti, where he arrived on the 11th. The Dupetit-Thouars having sailed, he was forced to return, and on the 18th he arrived at Yavisa.

On the 19th the expedition left Yavisa for Panama, where they arrived on the 25th.

On the 5th of March M. Sosa commenced a tacheometric survey of the valley of the Caïmito. On the 12th he was joined by M. Réclus, and afterwards by M. De Lacharme. They explored the valleys of the Bernadino, Caïmito, Aguacate, and Congo, and on the 28th returned to Panama.

On the 3d of April a survey of the valleys of the Obispo, Chagres, and Rio Grande was commenced near the station "d'Emperador," on the Panama Railroad, and was continued along the route of the railway until April 20. The level-lines and cross-sections were run up to the extremities of the proposed tunnel, and did not continue over the divide. On the 1st of May M. Réclus sailed for Europe.

On the 4th of June Messrs. Wyse and Verbrugghe returned to Panama, having obtained a concession which embraced the whole country of the United States of Columbia, thus including all the proposed routes except the Nicaragua and Tehuantepec. They left immediately for Greytown, looked at the harbor, and ascended the San Juan, held some correspondence with the President of Nicaragua, and then sailed for the United States.

From the above explorations, joined with those made in 1876–'77, the following plans for canals were devised. The dimensions proposed were: Breadth at bottom, 20 meters; at 3 meters from the bottom, 26 meters; at surface, from 32 to 50 meters, according to nature of soil; depth, 8.5 meters at mean low tide; tunnel, breadth at bottom, 20 meters; at surface, 24 meters; height above level of water, 34 meters. It was with these dimensions that the estimated prices were calculated; 25 per cent. was added to the prices so obtained.

FROM THE SURVEYS OF 1876–'77–'78.

First. A lock canal via the Atrato, the Caquerri, and the Tuyra. Length, 128 kilometers; height of summit-level, 50 meters; number of locks, twenty-two, ten on the Atlantic and twelve on the Pacific slope. The summit-level is a lake to be formed by dams in the valley of the Tuyra. Estimated cost, from 650,000,000 to 700,000,000 francs.

Second. A tide-level canal via the Tupisa, the Tiati, and the Acanti-Tolo. Length, including tunnel, 74 kilometers; length of tunnel, 17 kilometers; estimated cost, about 600,000,000 francs.

FROM THE SURVEYS OF 1877–'78.

First. San Blas, tide-level canal, via the Bayano, Mamoni, and Nercalegua Rivers. Length, 41.5 kilometers; length of tunnel, 15.8 kilometers; estimated cost, about 475,000,000 francs.

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Second. Panama tide-level canal via the Chagres and the Rio Grande. Length, 73.2 kilometers; length of tunnel, 7,720 meters; estimated cost, 475,000,000 francs.

THE PARIS CONFERENCE.

On the 15th of May, 1879, an International Conference was held at Paris, under the auspices of the Paris Geographical Society, for the purpose of deciding upon the best route for an interoceanic canal.

The "Société Internationale du Canal Interocéanique" had considered the project of this conference prior to its actual inception, hoping its decision would give an importance to their work and a value to their concessions. Of this "Société" M. Wyse and General Turr were the nominal exponents, M. de Lesseps the real power, "for it was by his advice that MM. Wyse and Réclus undertook their explorations, and the confidence of capitalists was stimulated by the certainty that he would put himself at the head of the enterprise when the moment for execution arrived."*

The explorations of the "Société" being finished and their concession obtained, a proceeding which M. Wyse characterizes as "perhaps the most important part of the mission with which I had, for a second time, the honor to be charged,"† an "International Conference" was called; M. de Lesseps, through the Geographical Society of Paris, issuing the invitations. He also selected the officers and the committees and mapped out their work before the meeting of the "Conference."

The "Conference" met on the 15th of May, 1879, M. le Vice-Amiral de la Roncière le Noury in the chair. After naming the five vice-presidents, general secretary, and four secretaries, he surrendered the chair to M. de Lesseps. Upon assuming the presidency of the Conference, M. de Lesseps made a short speech, in which he declared that they were going to work "à l'Americaine," and he thought they would finish in eight days. The names of the members of the committees, their presidents, and the work expected of them was then read; beyond this "nothing was done or allowed to be done."‡

The Conference was composed of one hundred and thirty-six members, of whom seventy-four were French, and sixty-two of different nationalities; forty-two were engineers or men fitted by profession to express an opinion on a purely engineering matter. Of this number thirteen had been connected with the Suez Canal, and several of the remainder have since been attached to the scientific corps of the Chagres Canal at Panama. The remaining ninety-four members were bankers, politicians, speculators, members of the geographical societies, and army and navy officers.

Four committees were appointed, designated by numbers, viz:

First. Statistics.

Second. Economic and commercial.

Third. Navigation.

Fourth. Technical.

Fifth. Ways and means.

The decision of the Conference was based upon the report of the "fourth committee" alone, and the struggle between the advocates of the different routes took place at its meetings.

This committee was composed of forty-two members, afterwards increased to forty-five; thirty-eight were engineers, eleven of whom had been connected with the Suez Canal. From this committee two sub-committees were appointed; the first on tunnels, composed of seven members, three of whom had been on the Suez Canal; the second on locks and dimensions of canal, composed of five members, three of whom had been on the Suez Canal.

A scale of prices was fixed and the dimensions of the Suez Canal adopted. Upon this basis a comparative table was formed of the cost of the different schemes. This created much discussion, the advocates of the different plans claiming that material modifications had been made by the sub-committees.

On the 20th of May, Mr. Menocal, C. E., called attention to the immense floods of the Chagres

* Extract from an opinion of M. de Lesseps, furnished by his counsel to the "Société Internationale," etc., June 10 and 17, 1879.

† Summary report of the expedition of 1877–'78, by L. N.-B. Wyse, commandant de l'expedition.

‡ Report of W. E. Johnston, delegate of the American Geographical Society. See Bulletin of the Society No. 4, 1879.

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River and the damage they would do to the tide-level tunnel canal proposed by Messrs. Wyse and Réclus.

On the 21st of May, Sir John Hawkshaw, one of the ablest engineers of our day, on whose individual opinion the Viceroy of Egypt depended in the matter of continuing or stopping the works on the Suez Canal, said:

"A tide-level canal would receive, and must provide for, the whole drainage of the district it traversed. Therefore, it would be necessary to ascertain the whole volume of water that would drain into the canal before it would be possible to determine even the sectional area of the canal. If the canal have a less surface fall than the river, as it would have, it must have a larger sectional area to discharge the same volume of water.

"The average section of the river in a flood at Mameï was ascertained by M. Réclus to be 1,310 square meters. This would require a canal, if it were 8 meters deep, to be 160 meters wide. The waters of the Chagres would have a tendency to flow toward the Pacific, that is, through the tunnel, as the distance is less and the fall is greater than to the Atlantic.

"It seems to me that the dimensions of the tunnel, if it has to serve for both the river and canal, would be too small. Mr. Menocal's estimate of the volume of the Chagres in time of flood would much more than fill the tunnel; and in any case the whole section of the tunnel is only half that of the river in time of flood, as given by M. Réclus. During the construction of a canal at the sea-level difficulties would arise in providing for the drainage, which would affect both time of execution and cost to an extent that could hardly be ascertained in advance.

"If, from such considerations as the foregoing, it should be concluded that the canal should be so constructed as to retain the rivers for natural drainage, then recourse will have to be had to locks. In that event, there can be no difficulty, in my opinion, in carrying on the traffic with locks properly constructed, provided there is an ample water-supply, which would be a *sine qua non*."

On the 22d, Messrs. Wyse and Réclus introduced an entirely new scheme, doing away with the tunnel and altering the route.

M. de Fourcy, formerly of Suez, asked an extension of eight days for the sub-committees to make their report. As the majority of the fourth committee did not seem likely to act on this motion, M. Daubrée, the president, adjourned it until May 26.

May 23, the day appointed for the different committees to submit their reports to the Conference, M. Voisin-Bey, of Suez, reporter of the fourth committee, laid before the Conference the work accomplished by his committee, and stated that it was not possible for them to formulate definite conclusions at this time.

M. de Fourcy, of Suez, asked that the final meeting of the Conference be postponed until the 29th. This M. de Lesseps granted.

On May 27, the fourth committee, on motion of M. de Fourcy, of Suez, separated all the schemes into the two following classes:

First, lock canals, comprising—

a. The two Nicaragua schemes of Menocal and Blanchet.

b. The two Panama schemes of Menocal and Wyse.

Second, tide-level canals, comprising—

a. The Panama open-air scheme of Wyse and Réclus.

b. The San Blas schemes of Kelley, Selfridge, and Wyse.

c. The Atrato-Napipi scheme of Selfridge.

All others were rejected.

On May 28, M. de Fourcy, of Suez, in the fourth committee, moved the following resolution be adopted:

"The committee, from the point of view for which it was instituted, is of the opinion that it should recommend to the Conference the adoption of a tide-level maritime canal from the Gulf of Colon or of Limon to the Bay of Panama."

A violent discussion followed, many of the members claiming that the resolution was too absolute. It was finally amended as follows, by M. Ruelle, and on motion of M. de Fourcy, put to vote:

"The technical committee believe that the interoceanic canal should be constructed between Colon and Panama."

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Of the forty-five members entitled to vote, twenty voted "yes," seven of whom had been engineers of the Suez Canal, and two were not engineers; nine abstained from voting, and sixteen were absent.

The next point of M. de Fourcy's original resolution, that they should recommend a tide-level canal, caused a stormy debate as to its form and expression. The president, M. Daubrée, finally closed the discussion and put to vote the following resolution:

"The technical committee, from the special point of view for which it was instituted, is of the opinion that it should recommend to the Conference, as the best solutions of the questions submitted to its examination, the establishment of a tide-level canal on the Isthmus of Panama, between Colon and Panama."

Of the forty-five entitled to vote, sixteen voted "yes," seven of whom had been engineers of the Suez Canal, and two of the remaining nine were not engineers. Three voted "no," ten abstained from voting, and sixteen were absent.

On the 29th of May the Conference held its final session. At the opening M. de Lesseps announced that in the final decision each member would be called upon to vote separately; that any one who wished to make known the reasons for his vote could do so, but if these reasons would involve discussions ("entraîner des développements") they should be reduced to writing, and sent as soon as possible to the secretary of the Conference, who would mention them in the proceedings. Abstentions from voting would not be counted, and a majority would be expressed by one more than one-half of the votes cast:

After giving the recapitulation of the principal schemes as prepared by the sub-committees of the fourth committee, the following resolution was put to vote:

"The Conference deem the construction of an inter-oceanic canal, so desirable in the interests of commerce and navigation, is possible, and in order to have the indispensable facilities of ease of access and of use, which a work of this kind should offer before all others, it should be built from the Gulf of Limon to the Bay of Panama."

This resolution was carried by the votes of seventy-eight members, nineteen of whom were engineers and professional men; of this number, nine had been connected with the Suez Canal; eight voted "no," twelve abstained from voting, and thirty-eight were absent.

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The Atrato-Napipi and Atrato-Bojaya routes.

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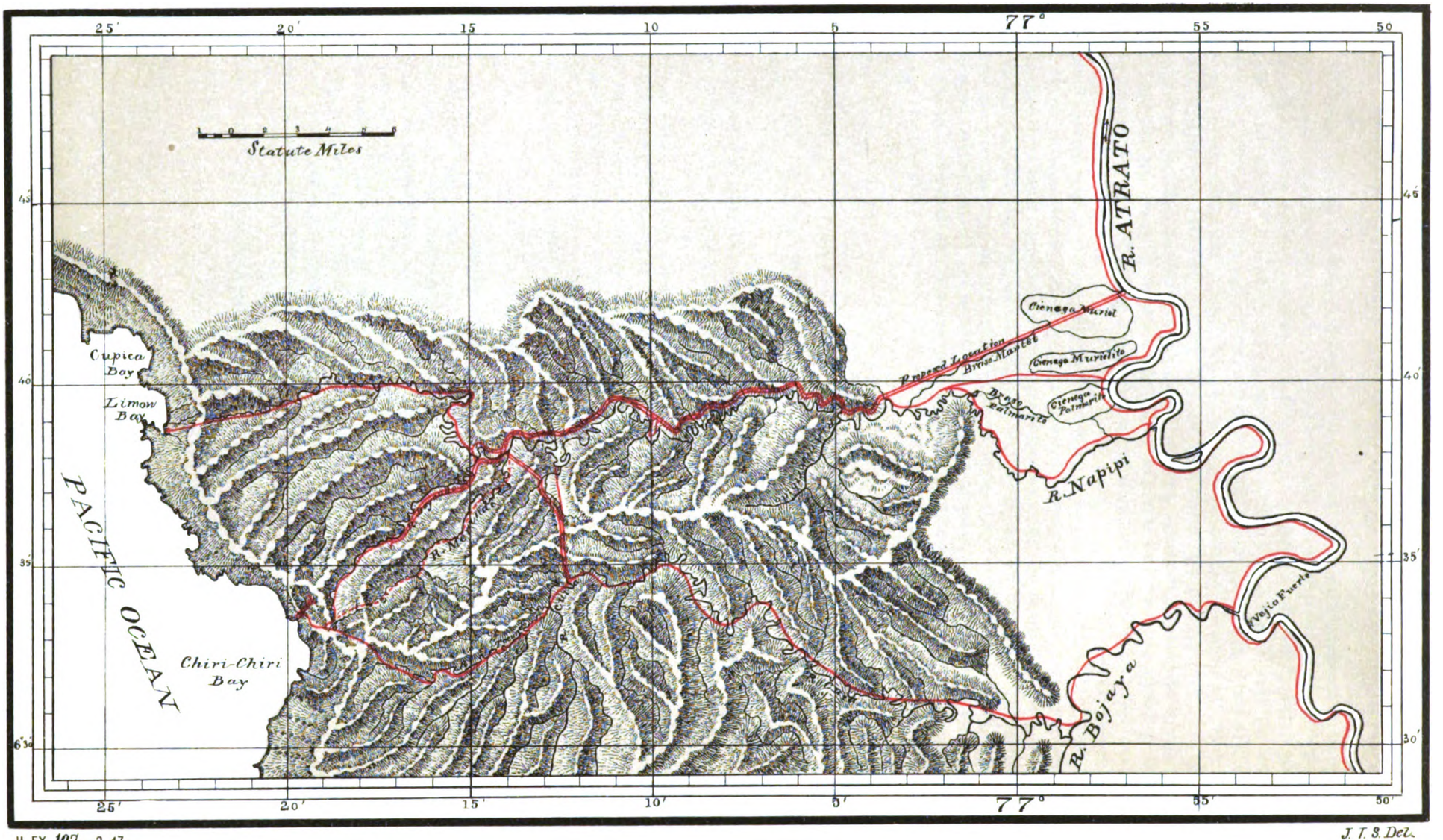

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CHAPTER XII.

TECHNICAL DESCRIPTION OF THE NAPIPI-ATRATO, TRUANDO-ATRATO, AND TEHUANTEPEC CANAL ROUTES, AND OF EADS'S SHIP-RAILWAY PROJECT.

The practicability of a route depends primarily upon its freedom from obstacles that cannot be overcome by engineering science, and ultimately upon the absence of insurmountable obstacles to its commercial success. The Napipi, Truando, San Blas, Panama, Nicaragua, and Tehuantepec routes are all practicable in an engineering sense; but the cost of construction, permanence, and usefulness of the work being considered, some of them become, if not absolutely, at least relatively impracticable. Of the above-mentioned routes the Napipi, Truando, and Tehuantepec are regarded in a general comparison as inferior to the remaining three. In the descriptions of the routes which follow, their general characteristics will be presented in order to show this, and the final comparison will be confined to the San Blas, Panama, and Nicaragua routes.

NAPIPI-ATRATO ROUTE.

The scheme for opening this route provides for making use of the Atrato River, from its mouth, in the Gulf of Darien, for a distance of about 140 miles, to a point on its west bank 10 miles below the mouth of the Napipi, and for the construction of a canal from this point to the Pacific coast, a distance of about thirty miles, up the valleys of the Napipi and Doguado Rivers. The bar at the Caño Uraba mouth of the Atrato would have to be removed; a tunnel 3½ miles long would have to be bored through the Cordillera, and it would be necessary to construct a harbor at Chiri-Chiri Bay, the Pacific terminus of the canal.

The direction of the canal proper is indicated on the map, which shows the line of actual location surveyed by Lieut. Frederick Collins, U. S. N., in 1875. For the convenience of a more detailed description, the canal line may be divided into four divisions:

	Miles.
Eastern division, from Atrato to point of crossing the Napipi	20.63
Middle division, from "crossing" to tunnel	4.81
Tunnel division	3.50
Western division	1.30
Total length of canal	30.24

For the first 5 miles of the eastern division the line runs through swamps. On reaching firm ground the water surface of the canal is brought well above the ground by the introduction of locks, which are so placed as to admit 14 miles of embankment in this division. Twelve locks, with a lift of 10.3 feet each, are introduced in this division, raising the summit-level to 143 feet above mean tide. By means of twelve culverts and the necessary side drains, the drainage of the northern side of the valley of the Napipi is provided for without the necessity of taking any of it into the canal. In three places in this division the canal has been carried across the Napipi in its sharp northern bends.

The crossing of the Napipi, to follow the valley of the Doguado, is to be effected by raising its waters to a sufficient height by means of a dam just below its junction with the Merindo.

The middle division, lying in the valley of the Doguado, extends from the basin thus formed to the tunnel. This division is 4.8 miles long, and the depth of the required cutting averages 90 feet. For the first 6,000 or 7,000 feet, however, the cutting is light, the deepest cut in that distance being only 45 feet. The length of the deep cutting is from 16,000 to 17,000 feet. The deepest cut is 245 feet, but this is for a short distance only, through the summit of a sharp spur. At the eastern portal of the tunnel the cutting is 225 feet deep. In order to keep the best ground in this division the river will have to be diverted frequently from its bed. Capacious side channels will also have to be constructed to carry the drainage of the steep hillsides to the basin.

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The tunnel required for passing the canal under the Cordillera and bringing it out on the Pacific slope, in the valley of the Chiri-Chiri, has a length of 3½ miles. Two forms of transverse section are first proposed. A selection depends upon the nature of the material to be pierced. First, for good solid rock, a trapezoidal form, with a segmental arch of 120°, the crown to be 86 feet above the water-surface; a width of 70 feet at water-surface; a depth of 27 feet, and sides battered 1 to 20. The arch to be formed of masonry, 5 feet thick at the spring and 3 feet at the crown, the whole to be well backed by concrete. Second, for unsound or badly seamed rock, an elliptical section, with a conjugate diameter of 70 feet at water-surface, and a semi-tranverse diameter of 86 feet above the water-surface, the section to be continued below so as to give 27 feet of water. With this section the arched lining is to spring from the water-surface with a thickness of 5 feet, diminishing, as before, to 3 feet at the crown. Both these sections give 1,846 square feet as the area of water-space. The first plan would require the excavation of 5,279,843 cubic yards rock, and the second plan 5,102,862 cubic yards rock. The amount of masonry required is in one case 203,498 cubic yards, and in the other 682,993 cubic yards. The cost of the tunnels would be $32,479,120 and $40,960,272, respectively. The form of tunnel finally estimated upon differed only in the width at the water-surface, which was reduced from 70 to 60 feet, and an increase in depth to 30 feet. With these modifications the tunnels would cost, respectively, $30,443,994 and $35,876,853. The mean of these amounts, $33,241,923, is presented as the probable cost of a tunnel 60 feet wide at the water-line and 116 feet high. If the width of 70 feet is regarded as essential, $3,560,000 must be added to the above estimate.

The western division includes the portion between the western portal of the tunnel and the line of 26 feet of water on the Pacific coast. Its length is only 1.3 miles, and it is occupied entirely by the "pointing-basin," by which the change of direction between the tunnel and the valley of the Chiri-Chiri is to be effected, and by the ten locks required to descend to, or ascend from, the Pacific. The harbor at this terminus may also be properly considered as forming a part of this division.

The water supply of the Napipi and its tributaries at the summit-level of the canal being insufficient, a feeder line 3.2 miles long, with a fall of 14 feet, would have to be constructed from the Cuia River, whose valley lies to the southward of that of the Napipi. This work involves the construction of two dams, a tunnel 9,230 feet long, and open cut excavation for 7,720 feet. Its estimated cost is $548,726. The daily water supply, at the lowest stage, would be about 12,000,000 cubic feet.

The harbor on the Atlantic side, in the Gulf of Darien, is all that could be desired. Engineering science could readily overcome the obstruction at the Uraba mouth, and the Atrato River affords a channel for the largest vessels up to and beyond the point where the Napipi enters it.

The proposed terminus on the Pacific coast, Chiri-Chiri Bay, is merely an indentation in the coast open to all winds from northwest to southwest. The bottom of the bay is mainly sand, and affords good holding-ground. Violent gales are of extremely rare occurrence in that locality, and but little trouble would be likely to be experienced for the want of a more land-locked harbor at this terminus. A heavy swell rolls in at all times. To protect the entrance to the canal from this swell, and to afford a refuge for disabled vessels, works of considerable magnitude would be required.

The following are the forms and dimensions of the canal prism:

Width at bottom	feet	72
Width at water-surface in earth cuttings	do	150
Width at water-surface in rock cuttings	do	98
Slope of sides in earth cuttings		1½ to 1
Slope of sides in rock cuttings, below water		½ to 1
Slope of sides in rock cuttings, above water		¼ to 1
Width of top of embankment	feet	9
Slope of embankments, interior		1½ to 1
Slope of embankments, exterior		2 to 1
Width of "bench" at 10 feet above water	feet	9
Width of locks, inside	do	60
Length of locks between miter sills	do	400

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In computing the cost of the work the following prices have been allowed:

	Per cubic yard.
Excavation in earth	$0 30 to $0 35
Excavation in rock	1 25 to 1 50
Excavation of tunnel	5 35
Arched lining of tunnel	20 00
Dredging	50
Hydraulic concrete for locks, dams, &c	7 00 to 8 00
Masonry	15 00

ESTIMATED COST OF THE CANAL.

Excavation and embankment	$28, 697, 398
Tunnel	33, 241, 923
Locks	5, 049, 214
Culverts	3, 031, 405
Side drains	2, 449, 953
Diversion of rivers	1, 670, 159
Dam for crossing Napipi	616, 057
Aqueduct	548, 726
Breakwaters at Chiri-Chiri	2, 163, 000
Improvement mouth of Atrato	817, 780
Light-houses	60, 000
Grubbing and clearing	191, 900
	78, 557, 515
Add 25 per cent. for contingencies	19, 636, 879
Total estimated cost of canal	$98, 194, 394

LOCAL ADVANTAGES AND DISADVANTAGES OF THE ROUTE, STATED BY LIEUTENANT COLLINS.

ADVANTAGES.

1. Shortness of the artificial channel required.

2. Good harbors. That on the Atlantic side is all that could be desired, while on the Pacific side there is deep water, with good holding-ground, and the region is seldom visited by violent gales.

3. The cutting mainly in rock or stiff clays. In such materials the excavation can be reduced to a minimum. The clay will form stable embankments, as little liable to wash from rains and at the water surface as any embankments can be, and its impervious character will greatly reduce losses of water from filtration and leaks.

4. The greater portion of the work to be performed lies in a healthy region for the tropics.

5. Abundance of good timber for construction.

6. Proximity of the heaviest work to the Pacific coast, rendering transportation of labor, plant, and supplies comparatively inexpensive.

7. Absence of high winds along the canal line. Transit would be seriously impeded in any canal that should lie through a region subject to violent winds.

8. Freedom from liability to terrestrial convulsions of a nature likely to affect the permanency of the works.

9. Absence of large streams or of deep valleys to be crossed at a high elevation.

10. Friendly attitude of the inhabitants.

11. Fertility of the soil. Under proper management the country in the vicinity of the proposed line could be made to produce the greater part of the supplies required for the subsistence of the laborers.

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DISADVANTAGES.

1. The necessity of resorting to a tunnel, involving great expense in construction, uncertainty in estimates of cost, and a probable increase in the difficulties attending transit, especially for large ships.

2. The steep descent of the Pacific slope, necessitating the grouping of a large number of locks, and thus increasing the liability of damage to the works.

3. Very heavy cuttings in the valleys of the Doguado and Chiri-Chiri.

4. Limited water supply during dry seasons.

5. Liability to damage to the works from sudden floods. It is believed that this contingency is well guarded against, but the liability to sudden and heavy floods in a hilly country subject to torrential rains cannot be overlooked.

6. Excessive rains likely to wash away embankments, &c., while in course of construction and to interfere generally with the progress of the work.

7. Shortness and uncertainty of the yearly periods well suited to the work of construction.

8. Undeveloped state of the country and scarcity of native labor.

9. Remoteness from the great commercial centers of the world.

THE TRUANDO-ATRATO ROUTE.

The characteristics of this route are not very dissimilar from those of the Napipi. The eastern terminus of the canal proper is located on the west bank of the Atrato, about 80 miles above the mouth of that river.

The scheme differs from that laid out for the Napipi in this: it contemplates a canal without locks. The project depends upon the practicability of turning a portion of the waters of the Atrato into the Pacific, thus forming a new arm or river flowing with a moderate current, through a tunnel under the Cordillera, into the Pacific.

The initial point of the proposed canal by this route is also its summit point. Its elevation above the sea is placed at 32 feet, at a low stage of the Atrato, and at 42.77 feet during extreme freshets. It was determined, theoretically, that the current of this new river would not exceed that of the Atrato itself, but rather fall below it. The proposed cut was to follow a straight course from the initial point across the swamps to the Truando, then to follow the general course of that river to the mouth of the Nercua, a tributary of the Truando, thence a short distance up the Nercua to the mouth of one of its tributaries, the Grundo, where it leaves the Nercua Valley and, after piercing the Cordillera with a tunnel 12,250 feet in length, strikes the Chuparador, on the Pacific slope, and follows that stream to the Paracuchichi, which leads it to the ocean.

The dimensions of the canal were to be 100 feet at surface of the water and 30 feet deep. The height of the tunnel was to be 100 feet above the water-line. The length of the cut from the Atrato to the Pacific would be 43.2 miles, and the total excavation would amount to 151,300,100 cubic yards. The cost of the work was placed at $134,450,154. In the estimate of cost the following prices were used:

	Per cubic yard.
Cost of tunneling, including the heading	$2 50
Ordinary rock cutting	1 50
Earth excavation	33

It will be observed that the price allowed per cubic yard of tunneling is $2.88 less than that allowed on the Napipi route, and that in addition to this there is an allowance of $20 per cubic yard on the Napipi route. The estimated cost of the Truando tunnel is $13,995,000. Applying the prices allowed for the Napipi, this amount would be increased by at least $22,000,000, making the cost of the tunnel, in round numbers, $36,000,000, and the cost of the canal at least $156,000,000. If it were possible to construct the work for this price and furnish a channel-way free from locks, dams, and other hinderances to navigation, the project would be entertained in advance of a lock-canal costing less, but the problem of controlling the flood waters of the Truando Valley cannot be easily solved, and this element of uncertainty is in itself sufficient to condemn the scheme.

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The Isthmus of Tehuantepec, from the Gulf of Campeche to the Gulf of Tehuantepec, showing line proposed for the canal and the projected line for a ship-railway, the blue tint indicating the latter.

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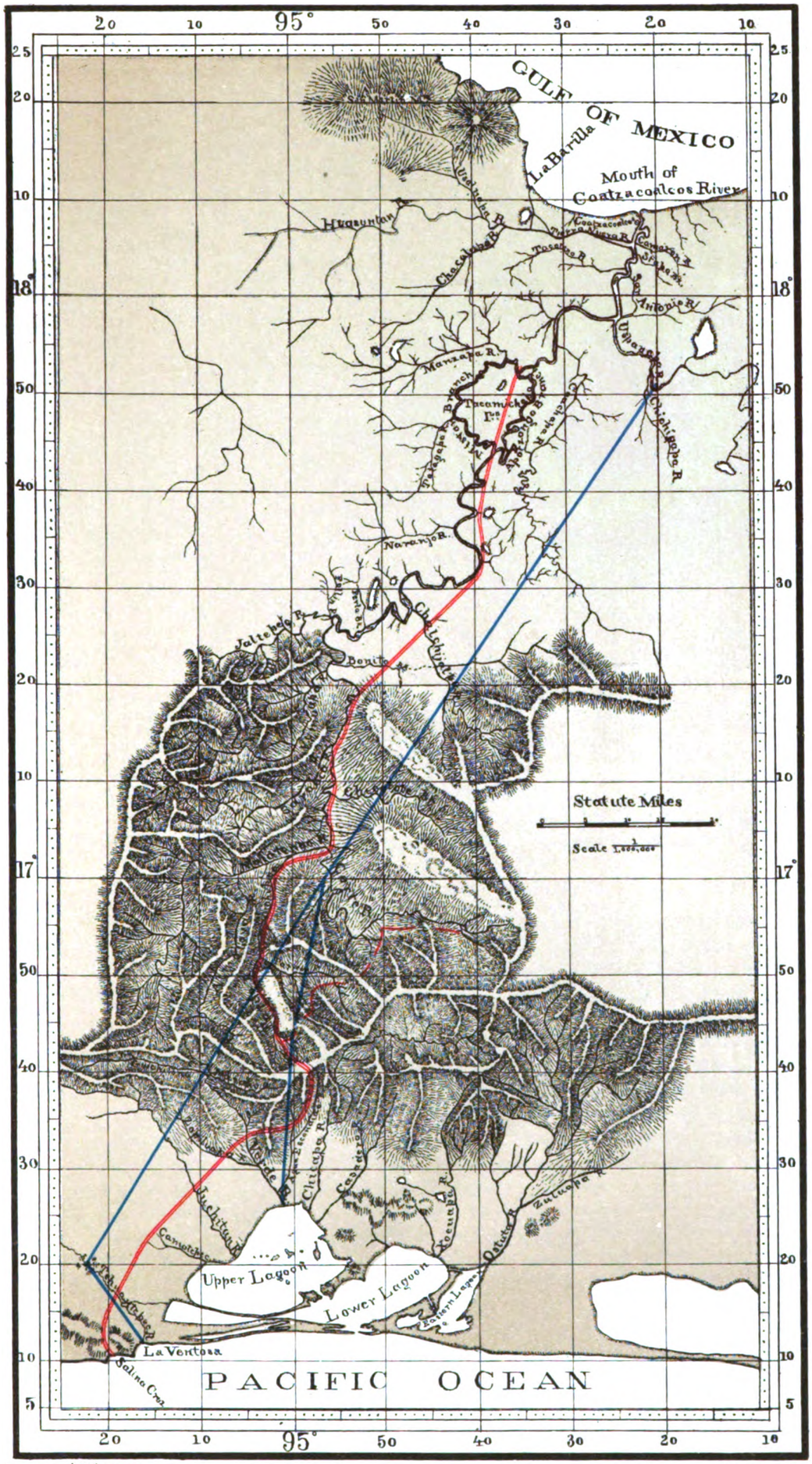

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THE TEHUANTEPEC ROUTE.

This route lies between the mouth of the Coatzacoalcos, on the Atlantic, and the port of Salina Cruz, on the Pacific. The projected canal commences at the head of ship navigation in the Coatzacoalcos, at the island of Tacamichapa, thence through the valley of that river to the dividing ridge at Tarifa Pass, thence to Salina Cruz.

The projected line is 144 miles long, and one hundred and forty locks would be required to overcome the elevation of the summit level, which, by a cut of 22 feet, is reduced to 732 feet. Twenty-two miles of river navigation are included in the above distance. The dimensions proposed for the canal were: breadth at surface, 62 feet; at bottom, 60 feet; depth, 22 feet.

To supply water at the summit level of the canal, a feeder would have to be constructed. This work involves a dam 122 feet long and 86 feet high across the Coatzacoalcos, near its junction with the Blanco, and at a point on this latter river about half a mile above this junction a dam 16 feet high and 140 feet long. A cut is then to be made above the dams to join the waters of the Blanco and Coatzacoalcos. To convey this water to the summit, a feeder canal, 27 miles long, involving 3 miles of heavy cutting, 3½ miles of tunneling, and 1,200 feet of an aqueduct, will be required.

The Pacific terminus of the canal would require for its protection a breakwater 2,000 feet long. On the Atlantic side there is good anchorage in the Coatzacoalcos, but the best channel over the bar, at the mouth of the river, has a depth of only 15 feet. It is believed, however, that a suitable channel can be made and easily maintained.

No estimate was made of the cost of the work. Adopting the same prices used in ascertaining the probable cost of the Nicaragua Canal, the engineer's estimate would amount to $130,000,000.

The plan adopted by the Commission appointed by President Grant was to reject the 25 per cent. usually allowed by engineers to cover contingencies, and in its place use 100 per cent. This, applied to the Tehuantepec scheme, would make the cost amount to $260,000,000.

In view of the many objections to this route for the purposes of a ship-canal it is hardly worth while mentioning any advantages which it possesses in point of location. The objections are: its great length, the number of locks required, a reasonable doubt as to the sufficiency of the water-supply, the effect of the severe northers blowing across the plains of Tarifa, which would be to stop transit for periods varying from a day to two or more weeks, and, finally, its great cost.

SHIP-RAILWAY PROJECTS.

It appears that the scheme of an interoceanic ship railway was proposed by Dr. William F. Channing, of Providence, R. I., during the discussion which preceded the construction of the Panama Railroad; and that later, in 1865, he secured a patent for a method of transporting vessels on a multiple track railway. His method included the ship-car and cradle, tilting-tables for overcoming changes in grade, and turn-tables to effect changes in direction.

About ten years ago, 1872, the Government of Honduras, anxious to establish an interoceanic transit through her territory, adopted the project of a ship-railway. The Government had previously negotiated several loans in Europe for the construction of an interoceanic railway from Port Caballos to the Bay of Fonseca, but as they had met with certain "mischances" it was decided to negotiate a fourth loan "for the alleged purpose of converting the partially constructed line into a railway for carrying ships of large burden, with their cargoes, across Honduras."*

In the "Historical account of the mischances in regard to the construction of a railway across the Republic of Honduras," Señor Ferro states that "when the project for converting the line into a ship railway was laid before the public it was hoped that the idea would be sufficiently supported to afford means for finishing provisionally the line already begun, and afterwards, according as the enthusiasm of the public was displayed, to go on with the works for converting the line into a ship-railway, or to abandon the project."

*All the quotations referring to the Honduras project are taken from Parliamentary Papers, "Loans to Foreign States," Report of Committee, 1875.

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In March, 1872, arrangements were completed to place the loan, but in May following the Honduras Government, through Don Carlos Gutierrez, withdrew the same.

The scheme proposed in this instance, to effect the transit of loaded vessels, is explained in the following letter, taken from Appendix V to the "Historical account" already referred to:

SHIP-RAILWAY ACROSS CENTRAL AMERICA.

"In order that a ship-railway joining the Atlantic and Pacific Oceans should prove of any real service, it would be necessary that it should be capable of accommodating vessels of at least 1,200 tons burden, and that it should be so constructed that, if necessary, it could be modified so as to take larger ships. A vessel carrying 1,200 tons would weigh about 800 tons and would not exceed 200 feet in length. We have, therefore, to provide a railway capable of carrying a vessel 200 feet long, and weighing with its cargo 2,000 tons.

"The carriage on which such a ship would be placed should be supported upon a very large number of wheels to prevent the weight on each being greater than could be dealt with, and for the present we may assume two hundred and forty as being about the necessary number. The number of rails which it would be most economical to adopt would be about six, and that number is taken as the basis of calculation.

"The number of wheels on each of the six rails would be forty, and it becomes necessary to consider how these wheels can be taken around curves. In the case of a curve of 2,000 feet radius, the versed line of an arc whose chord is 200 feet, is 2 feet 6 inches; and it therefore follows that the middle wheels, which must be in line with the end wheels on a straight line, must be 2 feet 6 inches out of line in passing round a curve of 2,000 feet radius.

"It is quite possible to arrange that the wheels should have a lateral motion equal to this, and also that the axles should be radial or nearly radial to the track; but as the play mentioned is probably as much as could safely be given, it follows that curves of 2,000 feet radius are the sharpest that can be adopted.

"The carriage would work most easily if the 240 wheels were placed in sixty bogies, those at the ends being fastened to the carriage in the usual manner by bogie pins, and those at the other parts being fastened by links, so as to admit of there being a lateral motion. Such a carriage could be easily constructed, and would weigh about 600 or 700 tons, and probably cost about £20,000.

"Seeing that the total load of carriage, ship, and cargo would be about 2,700 tons, and that the number of wheels is 240, it follows that the load upon each wheel will be between 11 and 12 tons on the average; but as it will be impossible to distribute the load equally among so many wheels, it will be necessary to be prepared for a somewhat greater weight. The rails of a sufficient strength would therefore weigh not less than 120 pounds per yard, and the best arrangement would be to lay the six rails each 5 feet apart, making a total width of 25 feet.

"The best foundation for this road would probably be wooden cross-sleepers 30 feet long, especially at first and until the banks became quite solid, when, if the timber was found to decay rapidly, it might be replaced with iron; but this need not be done for many years, by which time some definite idea may be formed of the nature and amount of the traffic and of the points of detail, which might be altered with advantage.

"The power requisite to pull this carriage and load on a level line would be about 27,000 pounds; and on a gradient of 1 in 50, 57,240; and on a gradient of 1 in 100, 87,480 pounds. To perform this work with ordinary locomotives would require from four to ten locomotives, according to the state of the rails, whether damp or otherwise.

"As the speed need not be great, it would appear better to adopt some means by which the locomotives should be independent of the state of the weather. This can be done by laying a rack along the railway, each locomotive having two toothed wheels which should work in the teeth of the rack, and by working these through gearing, as is done in traction engines and in some contractors' locomotives, it is possible to increase the tractive power of the engine by diminishing the speed.

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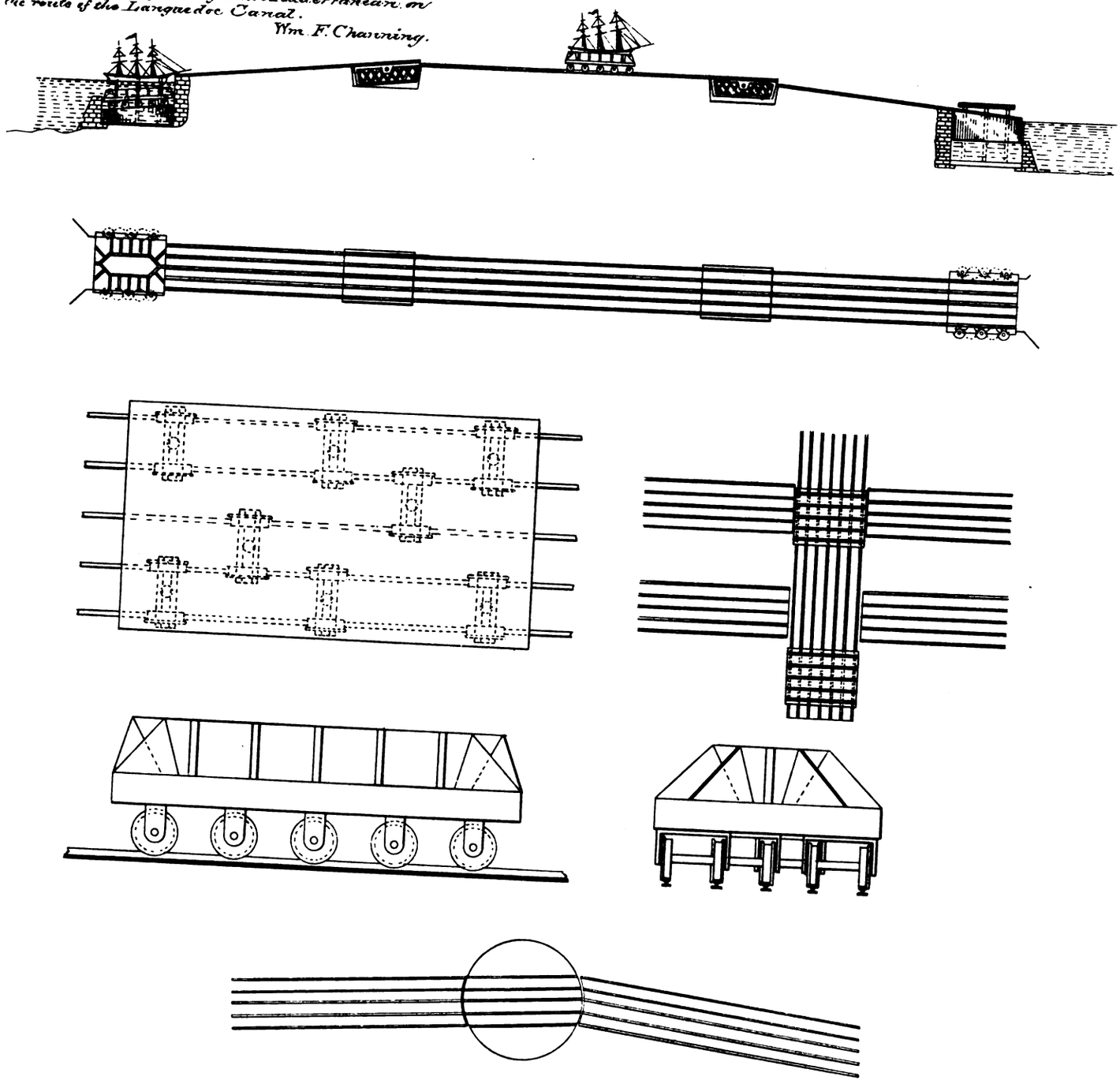
Exhibit No. 3.

Copy of a Drawing prepared for submission to the French Government in 1865, for a Ship Railway between the Bay of Biscay and Mediterranean on the route of the Languedoc Canal.

Wm. F. Channing.



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Wm. F. Channing.
1865

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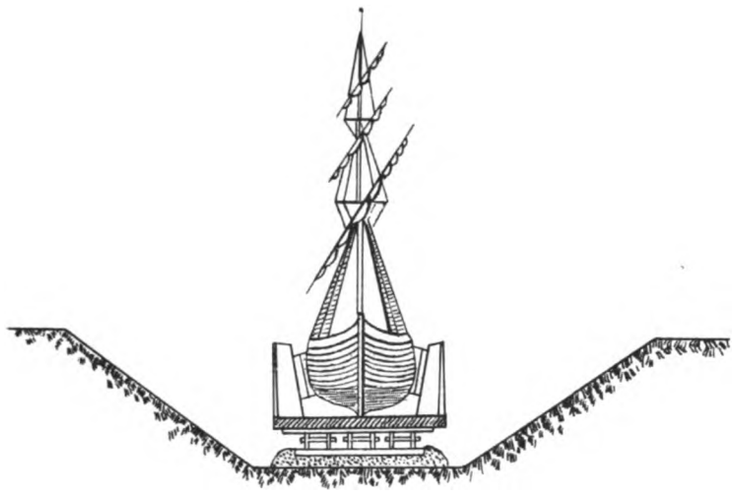
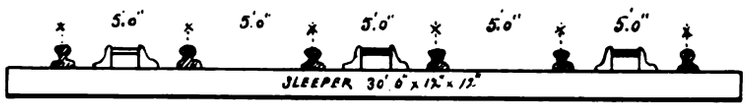
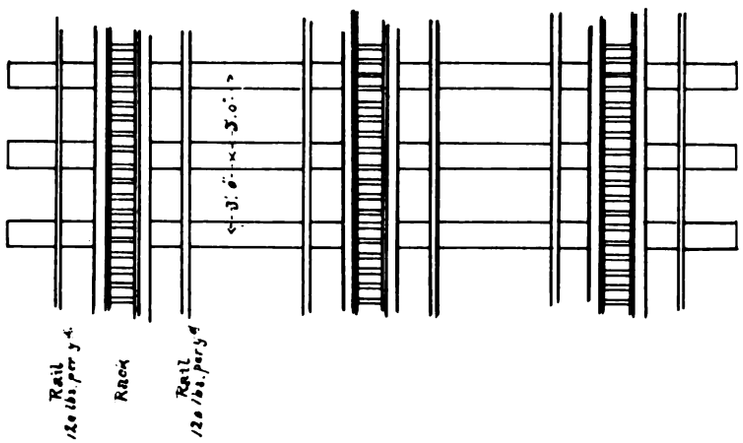
CROSS SECTION OF CUTTING.



CROSS SECTION OF PERMANENT WAY



PLAN OF PERMANENT WAY



The rack is composed of two large angle irons, with pins for teeth, so that there is no possibility of its being stopped up by dirt. Only one rack will be placed on level portions.

Honduras Interoceanic Ship Railway

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"For the purpose of raising the ship out of the water and placing it on the carriage, a hydraulic lift could be made use of, similar to those used for floating graving docks. By this system a ship is raised bodily out of the water and floated away on a ponton for repairs; and for the purpose of this railway a ship could likewise be lifted and placed on a carriage for transport. The details of this process would be varied but the principle would be precisely the same, and seems superior for this purpose to any description of inclined road like a patent slip.

"If these methods be adopted, there can be no difficulty in constructing or working a ship railway, provided the means at the engineer's disposal be unlimited; and it only remains to estimate the cost of such a line and to consider whether the traffic would be likely to give a proper return on the capital.

"To estimate the cost of earthwork and bridges without a section is impossible, and a section of an ordinary railway with curves of 330 feet radius gives very little idea of what the section would be if curves of 2,000 feet radius were used. The estimate of this part of the scheme must be taken as a good guess, probably not very far wrong, but possibly somewhat wide of the truth.

"In constructing such a line high banks should not be used, as they are liable to settlement, and it will therefore be necessary to allow a larger proportion than usual for cuttings.

"Tunnels are, of course, out of the question, and this again will cause an additional amount of cutting and increased expense. Under all circumstances, it would not be safe to estimate less than 400,000 cubic yards of cutting per mile.

The cost of one mile of permanent way, constructed according to sketches on the following page, would be:

Rails, 566 tons, at £12	£6,792
Fishes, 44 tons, at £14	619
Fastenings, 35 tons, at £20	700
Rack, average, 300 tons, at £24	7,200
Sleepers, Nos. 1760 at 90*s*	7,920
Ballast, Cy. 53,000, at 3*s*	7,950
Rail-laying, Ly. 1,760, at 10*s*	880
	32,058
The allowance for bridges may be taken, at per mile	10,000
The cost of one mile of earthwork would be, 400,000 cubic yards, at 2*s*. 6*d*...	50,000

"These figures, which may be taken as something near the mark, give the means of calculating the cost of a line 230 miles in length, which would be the length of a line across Honduras.

"The estimate would be as follows:

230 miles earthwork, at £50,000	£11,500,000
230 miles bridges, at £10,000	2,300,000
5 miles passing places, at £50,000	250,000
235 miles permanent way, at £32,000	7,520,000
400 locomotives, at £3,500	1,400,000
100 carriages, at £20,000	2,000,000
Docks and hydraulic lifts	430,000
Workshops, etc	400,000
Total	25,800,000

"To this must be added the cost of engineering, management, interest on capital during construction, etc., making a total capital of, say, £30,000,000, which cannot be considered, after all, an extraordinary amount when the enormous advantages which will accrue to the commercial world from the opening of a ship-railway across Central America are borne in mind.

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"According to official reports presented to both Houses of Parliament by Her Majesty's Government, the total tonnage cleared on shipment round Cape Horn is as follows:

	Tons.
To and from Great Britain	16,000,000
To and from other European countries	10,000,000
To and from Central America	8,000,000
To and from United States of America	20,000,000
Total	54,000,000

"Now, supposing that less than one-half of the said tonnage, viz, 25,000,000, passes over the intended ship-railway across Honduras, and a sum of $4, or 16*s.*, only is charged per ton, leaving, after deducting 50 per cent. for working expenses, $2, or 8*s.*, net per ton, the ship railway would pay a net sum of £10,000,000 sterling per annum, which would be more than three times the amount required to pay 10 per cent. interest upon the outlay of £30,000,000 sterling.

"It is, therefore, evident that a ship-railway across Honduras would be a profitable enterprise for the Government as well as a great boon for the commercial interest of the world.

"JAMES BRUNLEES.

"5 VICTORIA STREET, WESTMINSTER, *May* 8, 1871."

The most remarkable statement in the above letter is that relating to the amount of tonnage passing annually around Cape Horn. Instead of sending 16,000,000 tons around Cape Horn, England's tonnage for 1870, by that route, did not exceed 2,000,000 tons. Referring to this fact, there appears in the minutes of evidence contained in the report quoted from the following extract from an article in the Economist of the 25th May, 1872:

"This is fundamental truth (for everything depends upon the tonnage to be carried). Being so different from the statement in the prospectus, we do not care to examine too nicely its subsequent figures, especially as they relate to a complicated problem in dynamics and hydraulics as to which hardly any one has much experience. If what we can test is so very wrong, what we cannot test may be as wrong, too. We cannot return to speculate on the probable profit or loss of so strange an undertaking; it is much too remote from actual data for any solid or well-grounded estimate. The lenders of the money will in our judgment, therefore, have to look not at the profits of the railway, which are figures in the air and may never be realized, but to the good faith and pecuniary resources of the State of Honduras."

TEHUANTEPEC SHIP RAILWAY.

The scheme proposed by Capt. James B. Eads to effect an interoceanic transit for vessels and their cargoes by this route is essentially the same as that of Dr. Channing; but it has been developed to a greater degree in points of detail. It does not appear that a line of actual location has been determined upon for the railway, but the projected routes are indicated on the accompanying map of Tehuantepec.

The Atlantic terminus of the railway is reached from the mouth of the Coatzacoalcos by using that river for 25 miles and then by means of a ship-canal through the swamps for 29 miles. Here a system of twelve rails is to be laid, extending 3,000 feet into a dock of masonry, fitted with a gate or caisson so that it can be pumped out when repairs need to be made. The grade of the bottom of the dock, and consequently of the railway, is 1 foot in 100 feet. From this initial point of the road the railway pursues a series of straight lines, all changes of direction, estimated to be three, being made by turn-tables, passes over the divide, 732 feet above the level of the sea, and descends to the Pacific coast, 110 miles from its starting point. Here a dock, similar to the one already mentioned, built in one of the lagoons, whose common entrance is the Boca Barra, forms the Pacific terminus of the railway. The maximum grade allowed is 2 feet in 100 feet, or 105.6 feet per mile.

The cars for transporting the ships are to be built of a series of plate-iron cross-girders, extending across the whole width of the twelve rails, and running upon wheels which are 2 feet in diameter, placed 3 feet apart. Each wheel is borne upon a separate and independent axle so

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arranged that it can be easily removed and replaced in case of accident. Upon this car is a cradle, with keel and bilge-blocks, and all other supports necessary for keeping a ship in an upright position. The car is to be 100 feet shorter than the vessel which it is intended to carry, so as to give an overhang of 50 feet at each end. The motive power is furnished for the submerged ends of the road by a stationary engine. Over the remainder of the route two powerful locomotives, each resting on six rails, are to be used.

The method of operation proposed is that the stationary engine would back the car with its cradle down into the dock; the ship would then be floated over this cradle and the various supports put in place. When adjusted to its position, the car and ship would be drawn up the incline by the stationary engine. The two locomotives would then be attached to the car and take it across the mountains at the rate of at least 6 and possibly 12 miles an hour.

To provide for the passage of ships going in opposite directions and for repairs, turn-outs are to be conveniently placed. The change of direction from the main track to be accomplished by means of a turn-table.

The scheme of an interoceanic ship railway is so novel and bold as to seem particularly adapted to the progressive fancies of the American people, who have so often proved to the world the practicability of many enterprises that were declared visionary. But in the present instance, although the project is purely American the testimony as to its practicability comes mainly from foreign sources. This fact is significant. No nation would be so much benefited by such a transit as the United States, and the keen foresight of the American merchant, developed in the progressive school, would not fail to see the advantages such a transit would yield to our commerce, and his self-interest would compel him to approve of the scheme if in the chances for its successful operation there were not too many doubtful elements.

In determining the practicability of a canal route, the opinion of the engineer, the merchant, and the statesman is required; but to arrive at a correct conclusion regarding the feasibility of a ship-railway transit, it is necessary to add to this list of experts those who build ships, those who handle them in the water and out of it, and of those who assume risks upon the vessel's lifetime at sea.

The principal points to be considered with reference to the practicability of constructing and operating successfully an interoceanic ship railway are:

1st. Can a roadway be built in an isthmian country that will have the necessary solidity and permanency to maintain the system of rails, of each section, in the same plane and permit the transportation of great weights massed in a comparatively small area?

2d. Can a loaded vessel be taken from the water and be supported in a car without sustaining unequal and unprovided-for strains upon her hull; and, if such support can be given at rest, is it possible to overcome the inertia of the loaded car and maintain its motion over the road-bed without imparting concussive, torsional, transverse, and longitudinal strains which would prove destructive to the vessel?

3d. If it were possible to transport the largest vessels, with their cargoes, without damage of any kind to the vessel so transported, would the ship railway offer any advantages to commerce that a ship-canal could not supply?

In the discussions which have taken place in relation to this scheme, there are many points involved in the above questions which, on the one hand, are barely covered by statements of their practicability, while, on the other hand, the opponents have stated their objections more in detail. In condensing the materials gleaned from the discussion, to satisfy the above questions, the argument on one side might lose some force. It is, therefore, deemed proper to present the statements of each side. These will be found in Appendix D.

The advantages claimed by the projector for the route and scheme are:

1. That it is the shortest route for the greater part of the tonnage that would use any canal.

2. That the prevailing winds are much more favorable to commerce than they are by any other route.

3. That it possesses superior advantages for the United States from a military point of view.

4. That it is situated in a state which is not only averse to European domination, but has the power to resist invasion.

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5. That it is more healthful than any of the other routes.

For the scheme it is claimed:

1. That it is entirely practicable.

2. That the cost would be one-half that of a canal having locks, or one-quarter of one without locks, between the same points.

3. That the railway can be built in one-third or one quarter the time required for a canal.

4. That, when built, ships of the maximum tonnage can be moved four or five times faster than by the canal.

5. That a greater number of vessels per day can be transported than would be possible by the canal.

6. That the capacity of the railway can be easily increased without interrupting its business; to meet either an increase in commerce or an increase in the size of ships.

7. That the cost of maintenance of the roadway and rolling stock would be less than that of a canal.

8. That the cost of operating the railway will be less than the cost of operating the canal.

9. That the railway can be located and successfully operated in localities when it is not practicable to construct a canal.

10. That it is possible to estimate with great accuracy the cost of a ship-railway and the time needed to build it.

In reply to these statements, the advocates of a ship-canal assert as follows:

1. It is not the shortest route for the greater part of the tonnage that would use a canal. Tables compiled by the Chief of the Bureau of Statistics, Treasury Department, contain data which show that it is the shortest route for only one-tenth of the tonnage that would have used a canal in 1879.

2. The prevailing winds and currents are not favorable to vessels using this route. The following authorities substantiate this statement: Wind and current charts, United States Hydrographic Office; meteorological charts, Depot des Cartes et Plans, Paris, 1874; current charts, British Admiralty, 1872; M. F. Maury, wind and current charts, North Atlantic.

3. The advantages claimed for the Atlantic terminus, from a military point of view, are not true for its Pacific terminus, and even were they, the United States could not easily take advantage of them. In fact, they make a blockade by any naval power especially easy.

4. It is true that Mexico is averse to foreign domination, but this includes American as well as European states. She is not able to resist invasion, as was shown in her war with the United States, and by the French occupation.

5. The climate is healthful for a tropical country, but not more so than other portions of the elevated table-lands of the Isthmus. On this or any other route all the resources of sanitary science will be required to keep a working force in fair condition.

To the scheme it is objected:

1. There is more than a reasonable doubt as to its practicability, as *all* the iron-ship builders in the United States, with one exception, and many of the ablest engineers, have declared it impracticable. The difficulty of moving ships, completely empty, down an incline of 1 foot in 12 feet, and frequently more, is well known.

2. As no such structure as the contemplated railway has ever been built, all statements as to its comparative cost with other structures are purely theoretical. Marine railways, launching ways, and the cost of construction of the bottoms of dry-docks, furnish a poor but at the same time the only practicable means of comparison.

3. The claim that the railway can be built in one-third or one-fourth the time required to build a canal is entirely theoretical, there being no data founded on facts from which to judge.

4. It is not clear how masses weighing 26,000 tons (the weight of a ship, cargo, and transporting car), 2,000 tons more than the weight of the Washington Monument before the last addition to it, can be carried at any speed approaching six miles an hour. In fact it is difficult to conceive how the load can be started at all, as it represents a single rigid weight. Traction engines, whatever their power, within practical limits, can never overcome the inertia of 26,000 tons, represented by a rigid car carrying a single rigid weight of 13,000 tons. Cars in a freight train are started pro-

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gressively. The locomotive moves forward, bringing its momentum to bear upon the first car, which, starting, imparts a less momentum to the next car in order, and this does the same, in a lessened degree, for the next, and so on. Each successive start of the locomotive gives rise to a like series of impulses to the cars until finally the entire train is in motion, and the same thing proceeds until the proposed speed is attained. Were the train massed in weight upon a single car, the locomotive could produce no effect upon it. The difficulty is well illustrated at the Georgetown canal incline. The weight with water in the pontoon is 400 tons, concentrated in a single car, the pontoon. The power is equal to 200 horses. The 400 tons is, in effect, on a horizontal road-bed, being balanced by equal weights, exerting all their gravity so as to aid in pulling the pontoon. If the car be arrested on the way, the machinery cannot overcome the friction of quiescence, and assistance of a powerful character becomes necessary.

Claims 6, 7, 8, and 9, are statements of what the projectors believe, not what they know. There are no known grounds upon which such claims can be based.

Referring to the claim that a greater number of vessels can be passed over the railroad in a day than by a canal, it is not apparent how, with a single set of tracks, and sidings which must necessarily be few, ships can be made to pass each other at a more rapid rate than in a canal whose basins can be located as nearly together as may be desired; this, too, without considering the liability to accident of the machinery operating the turn-tables.

10. The estimates of cost and time for construction may be given from purely theoretical considerations and from the comparisons with the cost of ordinary railways. These considerations do not, however, furnish such a positive basis as any moderately prudent man would require before investing.

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CHAPTER XIII.

TECHNICAL DISCUSSION OF THE LEADING CANAL ROUTES; SAN BLAS, PANAMA, AND NICARAGUA.

At no time in the history of the problem of interoceanic communication has it obtained such a conspicuous position before the world, and claimed so much attention, as it has since the call for the Paris Conference. One of the most important results of the action of that body was to provoke an active discussion of the problem in this country, where there existed the broadest comprehension of its magnitude and a correct estimation of the many difficulties in the way of its solution.

In the discussions of the various routes and projects which took place before the Committees of Congress, the American Geographical Society and the American Society of Civil Engineers are to be found nearly everything that can be said in favor of or against the leading routes and schemes; and it is from the proceedings before these bodies that the materials for the following discussions are gleaned.

SAN BLAS ROUTE.

This route lies between the Gulf of San Blas, on the Atlantic, and the mouth of the Bayano River, on the Pacific. It is the narrowest part of the American Isthmus, being only 30 miles from ocean to ocean. From the Atlantic to the head of Pacific tide the distance is only 19.5 miles.

The scheme suggested for this route by Mr. Frederick M. Kelley is that of a sea-level canal, involving, according to a survey executed by engineers sent out by him in 1864, a tunnel 7 miles long. It will be remembered that the surveys made by Commander Selfridge on this route indicate the necessity for tunneling a distance of at least 8 miles.

Rejecting the results obtained by Commander Selfridge, Mr. Kelley's projected line is 30 miles long, from ocean to ocean; of this distance 10 miles lie in the Bayano River, which he deems capable of improvement for the purposes of navigation, leaving 20 miles for canalization, which includes the tunnel, 7 miles long. In presenting this route for consideration, Mr. Kelley says: "The harbors at both termini are good, and the quantity of materials to remove for a canal 125 feet wide at the water-line, and 28 feet deep, is much less than on any sea-level route known; besides, the longest slope of open cutting is on the Pacific, the most free from floods, and much the driest side of the Isthmus; and the canal located *there* through an open plane out of reach of drainage, I believe, would cost less and remain more permanent than anywhere else." To illustrate the practicability of constructing the San Blas tunnel and to show the advance made in the execution of tunneling work he states:

"The Mont Cenis tunnel is 7 miles 1,044 yards long, 25.84 feet wide, and about 20.65 feet high. It is lined throughout with brick and stone. It was commenced in 1858, and was finished in 1871. During the first five years the work was driven and finished at the rate of 1,300 feet per year, but by means of improved machinery, drilling apparatus, etc., this rate was increased to 4,500 feet per year. The total cost of the work was $9,439,400, which was at the rate of $14 per cubic yard of rock, there being in the tunnel 682,543 cubic yards.

"The St. Gothard tunnel is 9 miles, 2,585 feet long. Its height and width are the same as in the the Mont Cenis tunnel. That work was completed in a little over seven years, at the rate of 6,110 feet per year. It cost $9 per cubic yard, there being 1,109,689 cubic yards, and the total cost being about $10,000,000.

"The San Blas tunnel will be 7 miles long, 80 feet wide at the surface of the water, and 140 feet high from canal bottom to crown of arch. The work can be driven forward at the rate of 5,000 feet per year, so that it can be completed in a little over seven years. The heading of the San Blas tunnel, containing 332,640 cubic yards, I have estimated at $20 per cubic yard, and the

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Map of the San Blas route, showing localities examined under Mr. F. M. Kelley's direction, and by the U. S. Darien Expedition of 1870.

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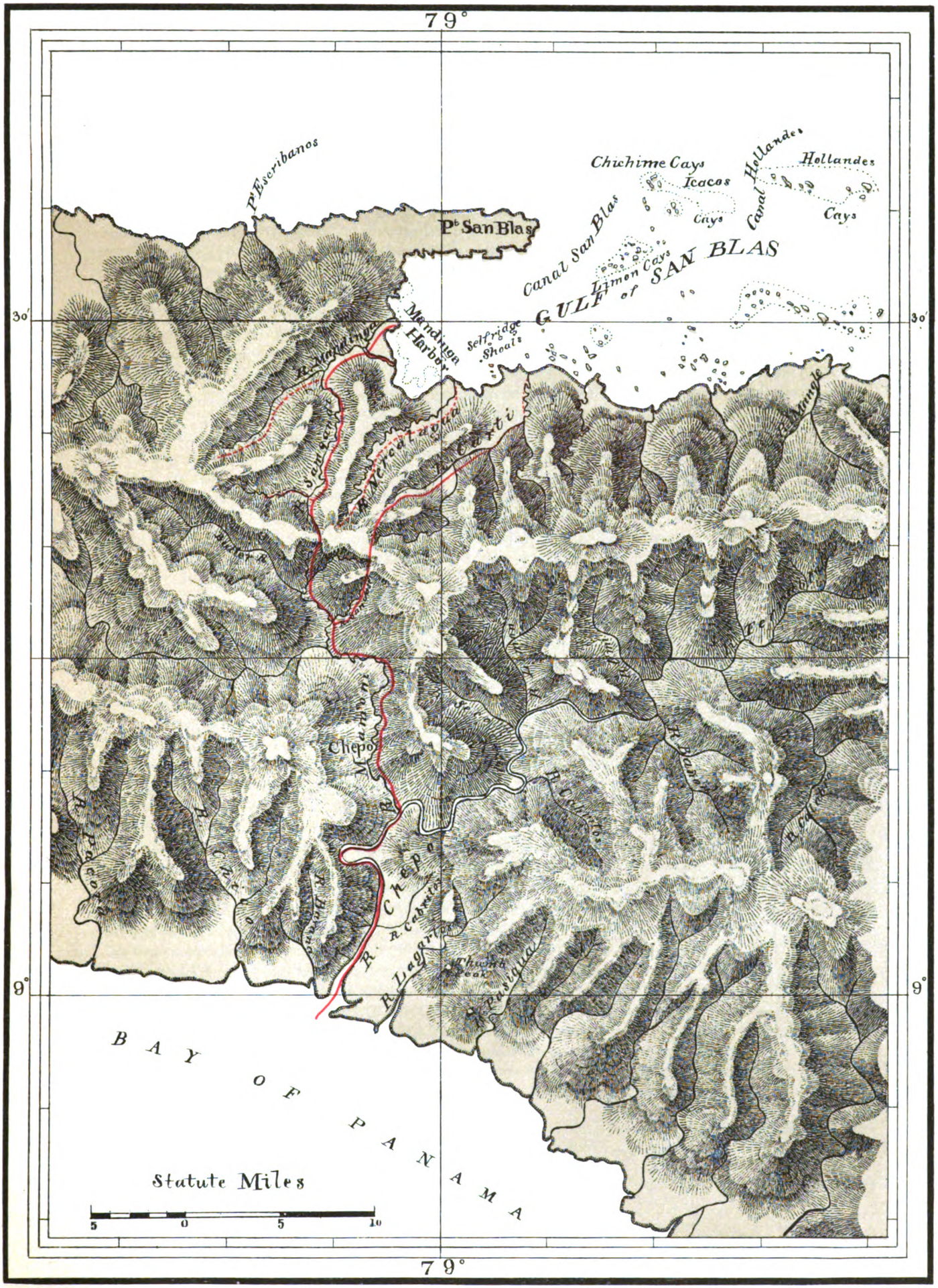

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breakdown on the part below the heading, containing 10,090,080 cubic yards, I have estimated at $5 per cubic yard. Of open rock-cutting there will be 15,011,219 cubic yards, which has been estimated at from $1.50 to $2 per cubic yard. Of earth excavation there will be 3,955,889 cubic yards, the cost of which is estimated at from 60 to 90 cents per cubic yard. Of masonry there will be 54,446,000 cubic yards, which is estimated at $15 per cubic yard. Concrete is estimated at $7 per cubic yard, and the cost of pumping is estimated at $2,000,000. The total cost is estimated at $104,017,780; that is, supposing the tunnel should require no lining. But if the tunnel should require lining, to that amount there is to be added about $30,000,000. Still, on account of the main back-bone of the Cordilleras being granite and outlying stone trap, I do not believe that any lining will be required.

"A canal via the San Blas route will give us a deep, wide cut through the narrowest part of the Isthmus, through which vessels may pass from ocean to ocean, quickly and cheaply, on an even keel, without the expense, dangers, and delays of locks, save one tidal lock to control the high tide of the Pacific. A ship, at the rate of three miles per hour, could be towed through the San Blas canal in ten hours, and thus one hundred going from the Atlantic to the Pacific, and one hundred from the Pacific to the Atlantic, two hundred ships could pass the Isthmus at this narrow point in twenty-four hours with perfect ease.

"The safest and most reliable material to excavate in that country is rock, and the more miles of rock the canal passes through, the more safe and durable will be the structure, the less walling will be required to keep the banks from falling in, and the less will be the maintenance after the work is finished. Of about 30,000,000 cubic yards of materials to be removed on the San Blas route (which is much less than on any other excepting the Atrato–Napipi). About 25,000,000 is rock, and hence the canal located there would be more safe and solid, and cost very much less to maintain in the future."

Mr. Sidney A. Shelbourne, an earnest advocate of the San Blas route, in the discussions which took place, proposes a larger tunnel. He says, "Considering that it might be desirable that the largest vessels now afloat should pass each other within the tunnel, one going in one direction and the other in the opposite direction, and considering the progressive size of the vessels of the future, I have made this tunnel 100 feet wide at the surface of the water. It is also 100 feet wide at a depth of about 14 feet below the surface of the water, and to a height of 54 feet above it. Angles are avoided in the bottom of this tunnel, and the sides are seen to curve inward towards the floor, leaving a convenient fillet of rocks in the corners. The height of the tunnel altogether, from the bottom to the top, is proposed to be 168 feet, with a depth of water of 28 feet. The springing of the arch is to begin at 54 feet above the surface of the water, and continue thence a further perpendicular height of 86 feet to the crown, making the latter point 140 feet above the surface of the water."

The method proposed for excavating this tunnel is to commence at the top section or heading of the main tunnel. This heading or preliminary tunnel will have a vertical transverse section of about 40 square yards, and conforming its arch with the arch of the main tunnel, will have its floor 15 feet below its crown and be about 30 feet in width; so that at the sides of the preliminary tunnel its roof would be 7 to 9 feet above the floor. "If a section of 40 square yards be assumed for this excavation, a length of 7 miles would give 492,800 cubic yards. The cost of this preliminary tunnel has been placed at $10 a cubic yard and would amount to $4,928,000. When the work I have just named is completed, all the tunneling work, which it is proper to name as such, is done. The rest is to be classed as work of another character. * * * It is clear to the mind of an engineer that when the preliminary tunnel is once driven the remainder of the work becomes nothing more than open cut work, with the extra advantage that you have the protection of a roof over you, so that the work with electric light can be carried on twenty-four hours a day the year round, without exposure to the vicissitudes of the weather or the malarial atmosphere of swamps and vegetable decay.*"

The cost of excavating this great tunnel is estimated, by Mr. Shelbourne, to be about $65,000,000; but if a tunnel with a width of 60 feet should be thought ample this estimate would be reduced to

* It is not likely that such favorable sanitary conditions would exist. I will give my reasons for dissenting from Mr. Shelbourne, at the close of the present discussion.—J. T. S.

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$40,000,000. M. Louis Favre, contractor for the St. Gothard tunnel, in estimating for a tunnel at San Blas, places the cost at $100,000,000.

The method proposed to excavate the tunnel is as follows:

"After the preliminary tunnel has been driven into the mountain on either side for a certain distance, a multitude of workmen are placed upon this open-cut excavation, and the tunnel is enlarged from the top downward in benches of rock and in convenient sections, always providing a depression for the drainage of infiltration. A track is laid in the tunnel and the *débris* is railroaded out on flats and dumped on either side of the proposed canal upon the low ground adjacent to the sea, and perhaps extending a certain distance into the harbor of Mandinga, and widening out on either side so as to form a convenient mouth for the canal."

Mr. Shelbourne thinks it as easy to haul excavated materials 3½ miles out of the tunnel as to haul out of a deep cut in a canal, and that it would be as easy to haul the material the distance mentioned as to haul it over the sides of a cut 100 feet deep. He states that "the Culebra section of the Panama route contains about 34,000,000 cubic yards of rock, while this tunnel on a comparative estimate contains less than 17,000,000 cubic yards of rock. Now, when the small heading is put through—a heading of 40 yards of section (while the St. Gothard tunnel has a section heading of 70 yards)—then every cubic yard of the remainder of that excavation for the tunnel becomes equivalent to a cubic yard of De Lesseps' excavation."

Mr. Shelbourne's interpretation of the data which bear upon the geological formation of San Blas leads him to expect that most of the rock found in piercing the Cordillera "will be sufficiently homogeneous to be self-sustaining." He adds, "If we should find as great a proportion of the length of the tunnel that would need arching as they found in the Hoosac tunnel, which would be in this case a trifle more than one mile, it is proposed that an arch be constructed resting upon abutments in the natural rock sides of the tunnel, 50 feet on the curve of the arch below its crown, which would make each segment or rib of the arch a length of 50 feet. Now, to construct that arch with these ribs made of cast iron would give about 75 per cent. more strength, with only about one-third of the dead weight of an arch made of the best stone, as granite, 5 feet in thickness over the whole space. A section of one of those ribs may be roughly represented by a plain letter T, with the head-stroke shortened and the body-stroke lengthened. The width of the head, which would be on the greater or outward curve, next to the rock, would be one foot, and the depth of the remainder of the section of the rib would be 2½ feet at the crown of the arch, and 3½ feet where it rests upon the abutment. A shoe or bearing-plate would be cast on either end, the full width of the head and depth of the section, the shoe, on the lower end, resting on the abutment, and the bearing-plate on the upper end coming in contact with that of its fellow at the crown. As these ribs would be placed close together, each successive pair in contact with the preceding, it will be seen that each foot in length of the portion of the tunnel arched in this way would be represented by a pair of these ribs. The metal in the ribs would be of a uniform thickness of two inches, with a fillet at the junction of the head with the body. * * * These segments of the arching being placed close to each other, side by side, the backs of the whole, when in position, would represent a continuous arch-roof of iron, and the space between this roof and the irregular rock above would be filled with concrete. The arch thus constructed could be rapidly and easily put in position, and the cost would be less than one-half that of a granite arch of the thickness I have named." To prevent rusting, he proposed "lining or sifting the mold with the elements of glass, or the powder of ground glass of the commonest description," and cast upon the ribs a coat of glaze.

He states that ample provision can be made to drain the waters of infiltration until reaching the sea-level, when the work of excavation will have to be carried on in consecutive sections of half a mile each, and large centrifugal pumps used to free a section from water while it is being excavated.

"The tide-lock upon the Pacific end of this canal would be constructed of a length of 1,125 feet and a breadth of 100 feet; the gates, instead of being double at either end of this lock, would be single, and would be sliding instead of folding gates, and move on rollers, the advanced end of the gate moving into a recess across the opening of the lock, so that the pressure from either side will not disturb it from its position as the tide may be high or low. These gates need not be tightly fitting, for, since the two oceans are the water-supply, the escape of more or less water in the one direction or the other is of no consequence. At the middle division of this lock there

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would be a slight contraction in its width, and here would be another gate of the same construction which would ordinarily be left open." This middle gate is provided in case of accident to either of the others, or in cases where ordinary repairs are necessary. With a lock constructed on the above plans he estimates that six vessels of 1,000 tons each could be passed through in one lockage.

The San Blas route possesses many attractive features and is without doubt the best suited for a sea-level canal, but there are unfortunately many weighty objections to such a scheme by this route even. With reference to the statements that both harbors are good, and that 10 miles of the Bayano can be made navigable, extracts will be presented from the report of Commander Lull, U. S. N., who was ordered, in 1875, to make a personal examination of the Bayano River. He states that, "Our soundings had shown from 25 to 30 feet of water in the channel for the first 3 miles from the mouth, then frequent bars with 10 feet, 8 feet, and finally not more than 4 feet, these growing more and more frequent and longer as we ascended the river. Just above Dr. Kratochvil's place we found a solid gravel bar some three-quarters of a mile in length, with scarcely water enough to float a canoe. Most of the others were composed mainly of mud, which is also deposited in large outlying flats off the mouth of the river. A strong tidal current at all times, and overwhelming floods during the rainy season would render abortive any attempt to dredge a channel in this stream, while up to the highest point visited by us, as said above, no location existed for a dam by which to provide slack-water navigation. We concluded that further examination, except at the river mouth, was unnecessary." This examination showed that the bar, which is said to be a shifting one, lay near the island of Chepillo and about 2 miles from the mouth of the river proper; and that there was a depth of only 12 feet of water upon it (reducing to low tide). Mud flats extended for several miles in every direction.

Regarding the scheme suggested for this route, Commander Lull says: "The cost of a tunnel of suitable cross section with masonry arch and of one mile in length, Mr. Menocal computes to be not less than $15,000,000, while for greater lengths the cost would be increased in a very rapid ratio, owing to the distance it would be necessary to transport materials excavated and those used in construction. It is not, in my opinion, safe to estimate for self-sustaining rock in a projected tunnel of so large dimensions, for although it might prove to be so, there is no means of ascertaining that fact beforehand, and the chances are, to say the least, as much against as for it. A tunnel of even 5 miles in length would thus cost between $80,000,000 and $100,000,000. The Bayano River cannot be utilized, and an independent canal would have to be built from the end of the tunnel to the sea."

It is well to remember that the contemplated tunnel is intended to satisfy the requirements of a sea-level canal, and that, in consequence, nearly 30 feet of subaqueous excavation will have to be made throughout its length. With reference to this point, Mr. Menocal stated before the American Geographical Society that he had "carefully examined what takes place in the wells, and in the gold and silver mines, and other excavations in that country, and I say that as soon as we reach about 100 feet below the surface of the ground, the filtrations become so great that many of the richest silver mines have to be abandoned, because pumps could not be obtained with power and capacity sufficient to keep them dry. Through the loose disordered masses, the results of volcanic action, that make up the isthmus, water filtrates with the greatest ease everywhere, and in great quantities. At the summit of the Panama Railroad, its highest point, which is 282 feet above the level of the sea, there is a spring of water that supplies all the engines of the road, and in addition so far exceeds the demands upon it that it runs down the gutters on both sides of the road. * * * What, then, will be the effect of digging below the level of the sea? From my knowledge of the geological formation of the Isthmus, I believe that, so far from encountering solid and regular strata, as they suppose, they will meet with all kinds of materials—limestone, trap-rock, sand, conglomerate volcanic deposits—everything, indeed, without regularity, and in the most bewildering variety, even within the narrowest limits. I have seen workmen there, in the digging of a well to a depth of no more than 50 feet, go through ten different kinds of materials."

Major Walter McFarland, United States Engineer Corps, was selected by the Canal Commission to make a report upon the Nicaragua and Napipi routes, which were at one time rivals for preference. He made a personal examination of both routes, and in his report there is a criticism of the Napipi tunnel which may profitably be quoted here, but it must be remembered that the San

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Blas tunnel, as projected, is very much larger than that proposed for the Napipi, both in regard to length and section, and this fact would make his estimates too low if applied as they stand. Treating of the Napipi tunnel, he says:

"In regard to the estimated amount of excavation which its construction would require, there appears to have been too close an adherence in the calculations to the geometrical form given by the cross-section, on account of the necessary irregularity of excavation in rock. An allowance of at least one foot in depth below the surface to be gained should be made, and as the perimeter of the cross section is 293 feet in length, the estimate would have to be increased, taking the length of the tunnel as given in the report at 5,233 yards, by 170,000 cubic yards.

"Arching will undoubtedly have to be resorted to in the construction of a tunnel of this width; and the estimate must, therefore, be increased by the amount of excavation necessary for receiving the arch, and by the amount of arched masonry required. Taking the thickness of the arch at 4 feet, the additional amount of excavation required would be 287,000 cubic yards; and the amount of masonry needed would be the same.

"If it should be found in opening this tunnel that the sides are not self sustaining, or are subject to slides, a lining of masonry would also become necessary; and this would require 490,000 cubic yards of excavation, and the same amount of masonry.

"In a work of this character it is necessary that some other means of communication than by water should be had, in order that assistance might be easily rendered in case of accident to the work itself or to a vessel passing through it. A roadway should, therefore, be constructed through the tunnel wide enough to admit carts or wagons passing each other on it. Such a roadway, 14 feet wide and 20 feet high, would require the excavation of 180,000 cubic yards more. It will be seen that even taking the low rate of $5.35, which the report* assumes as the cost per cubic yard for tunneling, and $25 and $15 as the cost per cubic yard of arch masonry and side-wall masonry, respectively, the cost of this tunnel may be found in actual construction to run up to $38,000,000, or more than double the amount estimated for. * * *

"I omitted mentioning when speaking of the tunnel that if it was bored at an average rate of 6 feet a day from any face the amount of material which it would be necessary to get rid of daily would be 1,333 cubic yards, weighing, if it were granite or limestone, 3,000 tons; and for every shaft that is made use of, double this amount would have to be hoisted out daily, if two faces were worked from it at the same average rate. This would require the removal of 250 tons per hour, if every hour of the twenty-four were employed, or more than 4 tons a minute. The average height through which it would have to be lifted is 400 feet. This gives some idea of the character of the work which the construction of this tunnel would involve. Its breadth is a little less than two and a half times the breadth of Mount Cenis tunnel, while its height is a little more than four times the height of the latter. Therefore, while it would require the removal of ten times as much material per linear yard, it offers but two and a half times as much roadway for this purpose, and it is hardly possible that it can be constructed at the same rate of progress as the latter, which was about 6 feet per day of twenty-four hours from each face."

The project of a tunnel,† if successfully carried out, so far as its construction goes, would still be subject to many objections. A convulsive effort of nature might in a moment destroy the whole work. Some new system of towing vessels through would have to be devised, and it would be quite a problem to deal with the smoke and gases arising from the steamers using the canal.

The principal object sought in the construction of a sea-level canal is to offer a safe and speedy transit for vessels, but inasmuch as no sea-level canal can be built without the introduction of a lock to overcome the difference between the Atlantic and Pacific tides, it is not an unobstructed water-way, and it is evident that a single lock limits the number of vessels which can enter or leave the canal as effectually as though there were a dozen intervening locks.

A last and an important objection to the San Blas route is that its Pacific terminus is in the region of "Doldrums." A sailing-vessel having passed through the canal into the Pacific, and whether bound for the south, west, or north, has but one course to follow, and that is to make the best of her way against light head winds and through calms for nearly 700 miles to the southward

* Report of Commander Selfridge, U. S. N.

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and westward until reaching the equator in 85° or 86° west longitude; here she will feel the influence of the southeast trade-winds, and can stand to the westward until reaching the most favorable point for turning to the north or to the south.*

*Mr. Shelbourne claims that men engaged upon tunnel work would be less exposed to the vicissitudes of the weather and the malarial influences of the country. I am of the opinion that the reverse would be the case; that no more unfavorable conditions could be found for human existence than would be developed in subterranean work on the Isthmus, and that these conditions would render the execution of work impossible.

The responsibility for advancing this objection rests with me. It would be impossible for me to give here all my reasons for believing as I do, but it is possible to indicate, in a general way, the grounds upon which the argument is based.

In 1846 Dr. Weir Mitchell, of Philadelphia, presented to the public an essay on the origin of malaria. In his study of the conditions under which malaria exists he invariably finds that its environment is that which is most favorable to the development of fungous life. By many conclusive arguments he demolishes the marsh-gas theory and fairly establishes his own, which, briefly stated, is that the specific character of malarial and other epidemics is due to the presence of certain forms of fungous life. He gives many illustrations to prove his theory, but for the present purpose a few only need be selected. He shows that every epidemic of the plague and cholera has been associated with an unusual development of the fungi; that the favorable conditions for the development of these forms of life are darkness and a damp, chilly, atmosphere; that when men have been exposed in swamps during many hours of sunlight in a country of a decidedly malarial character they have escaped without contracting disease, but during the same season and at the same place every man exposed during only a few hours of darkness became violently sick.

It is commonly believed that autumnal fevers are caused by the gases arising from the immense quantities of decaying vegetation. Tyndall proved by his experiments, carried out on the Alps, that putrefaction was caused by germs, borne on the atmosphere, coming in contact with an animal substance which had, through death, lost its power to struggle against their parasitic attack In the fall vegetation is killed and decay ensues. This means, if it means anything, that some other forms of life are thriving upon this death, for "death is life." To what family does this particular death give existence? The evidences are unmistakable; the fungi in almost countless species develop at a rate that is marvelous. Within the last few years a scientific commission, engaged in ascertaining the origin of the Roman fever, made an analysis of the earth, air, and water of the infected district, and upon experiment it was ascertained that a certain spore of a fungous plant when injected into the blood of an animal caused all the characteristic symptoms of malarial poisoning. These experiments, and those of a more recent date, conducted by M. Pasteur, indicate a relationship between malaria and the fungi.

If such a relationship does exist, it is natural to expect an unusual development of fungous life in a country of such a decidedly malarial character as the Isthmus. As an instance of such a relationship, I can cite an experience of nearly four months on board one of our war vessels stationed at Aspinwall during the rainy season. Out of a complement of one hundred and eighty officers and men only a few individuals escaped an attack of the Chagres fever, and the sick-list, always large, increased to such an extent that the commanding officer was compelled to take the responsibility of leaving his station without orders, and on the day of our departure there were eighty of the ship's company down with the fever. Here was an abundance of malaria; we will now see about its companions, the fungi. Several varieties appeared soon after our arrival; an increase in variety and quantity took place until the ship became completely surrounded and permeated with fungi. During the morning, when cleaning ship, it became necessary to sweep immense mushroom-like growths from the coils of rope, and when the sun appeared its rays were reflected from myriads of long, gossamer webs floating from every piece of rigging aloft. Between decks there was always a damp, musty smell, and during a single night blue mold would collect in large quantities upon shoes, books, and other articles in a state-room. A pair of cloth pantaloons left for a few days in a drawer would, when taken out, look and feel as though they had been soaked in a weak solution of flour-paste. An entirely new set of rigging and awnings was rendered unserviceable by mildew in the short period of our stay. If, under such conditions, favored by an occasional sea-breeze and intervals of sunlight and dry weather, the development of fungous life was so great and the sickness so general, what is to be expected in a subterranean passage where the most favorable conditions exist for the development of the fungi and the worst possible for human existence? Whether it is the fungus or something invariably associated with it that causes the poisoning is immaterial as far as the present discussion goes. The gloom of the tunnel, the constant shower of chilled water from its roof and sides, and its deoxygenated atmosphere would rapidly lower the tone of the human system far below the normal condition, and in this state it would be unable to combat successfully against the invasion of the poisoning element.

A little thought will satisfy any one that mosquitoes are indigenous to malarial localities. The paradise of mosquitoes is on the Isthmus. They, too, are active during intervals of darkness, and this suggests the thought that a relationship may exist between thme and the fungi. The question is often asked, For what purpose was the mosquito created? It is hard to realize its usefulness in inflicting its torments upon man and beast. My answer is, that as they exist in greatest numbers where they can get the most food, and as there seems to be a close relationship between the mosquito population and the malarial charaeter of a place, it would seem reasonable to suppose that their food consisted of the elements which generated the malarial influence, and that, therefore, when legitimately employed, the mosquito is engaged in devouring countless millions of spores or germs, which, if not thus destroyed, would render the locality totally uninhabitable by man or beast. The popular notion is that the mosquito must always have a blood

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THE PANAMA ROUTE.

This route lies between Aspinwall and Panama. The canal line follows generally the course of the existing railroad. It ascends the Atlantic slope in the valley of the Chagres River to its junction with the Obispo and in the valley of this river to the divide; on the Pacific slope it descends by the valley of the Rio Grande to the Bay of Panama.

There are two schemes suggested for this route, one a lock-canal and the other a sea-level canal. Commander E. P. Lull, U. S. N., surveyed this route in 1875, and, rejecting the last named scheme as impracticable, he estimated for a lock-canal of the following dimensions: Length from sea to sea, 41.7 miles; width at surface, 150 to 164 feet; at bottom, 60 to 72 feet; depth, 26 feet. The summit-level was placed at 123.75 feet, and was to be overcome by the use of twenty-four locks, having a lift of 10.3 feet each. They were to be placed twelve on each side of the summit. In addition, a tidal-lock at the Pacific terminus is necessary.

The Chagres River changes its course, near its junction with the Obispo, so much to the northeast that it lies directly across the line of the canal; this involves the necessity of carrying the canal over the river by a viaduct sufficiently elevated above the floods of the Chagres River to permit the flood waters to pass under it. The viaduct would be 1,900 feet long and elevated 44 feet above the bed of the Chagres.

The surface of the water in the viaduct would be the summit level of the canal. To supply this summit with water a feeder line would have to be constructed. To accomplish this it is proposed to dam the Chagres at a point 12 miles above the viaduct and raise its waters 36 feet above the ordinary level; thence the water would be conducted 10.2 miles, passing through seven tunnels aggregating 13,700 feet in length, and over two aqueducts into a receiving basin of 22 acres area. This basin is to be formed by the construction of a dam 1,760 feet long and 74 feet high from its lowest foundation, between two spurs of the range of hills forming one side of the valley of the Chagres. The basin is located about 1,000 feet from the Pacific end of the viaduct. The channel of the Obispo River has to be changed for a short distance in order to give room for the dam. The estimated cost to construct the canal is $94,511,360.

A channel would have to be excavated in the harbor of Panama for a distance of 9,200 feet, and at Aspinwall for a distance of 1,800 feet. A breakwater would also be required at the latter port in order to protect the entrance to the canal.

A lock canal by this route would cost twice as much as one through Nicaragua, and would be inferior in many respects.

ADVANTAGES.

The advantages claimed for the route are:

1. An open cut with but moderate average depth of excavation.
2. A comparatively short distance from sea to sea.
3. Fair harbors on either side.
4. Proximity to a well-constructed railroad.
5. Established communication which exists with the principal ports of the world.

DISADVANTAGES.

1. The prevailing calms of Panama Bay.
2. The want of materials for the purposes of construction.
3. The large annual rainfall.
4. The character of some of the swamp lands on certain portions of the line.
5. The amount of tunneling required for the feeder.
6. A doubt as to the sufficiency of the water supply at all times.

diet, but the number who fare thus sumptuously is to the whole tribe as the sands of Coney Island are to those of Sahara.

If I am correct in what I have stated about the mosquito, he would find a good feeding ground in the tunnel, and it is likely that myriads of them would infest the place. They might succeed in checking to some extent the development of the fungi, but at the same time they would be quite as successful in driving out a higher form of life, man.—J. T. SULLIVAN.

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The Isthmus of Panama, from Limon, or Navy Bay, to the Bay of Panama, showing the valleys of the Chagres and Rio Grande, and the lines of canal located therein; the red line indicates Captain Lull's location for a lock canal, the blue line representing M. De Lessep's location for a tide-level canal.

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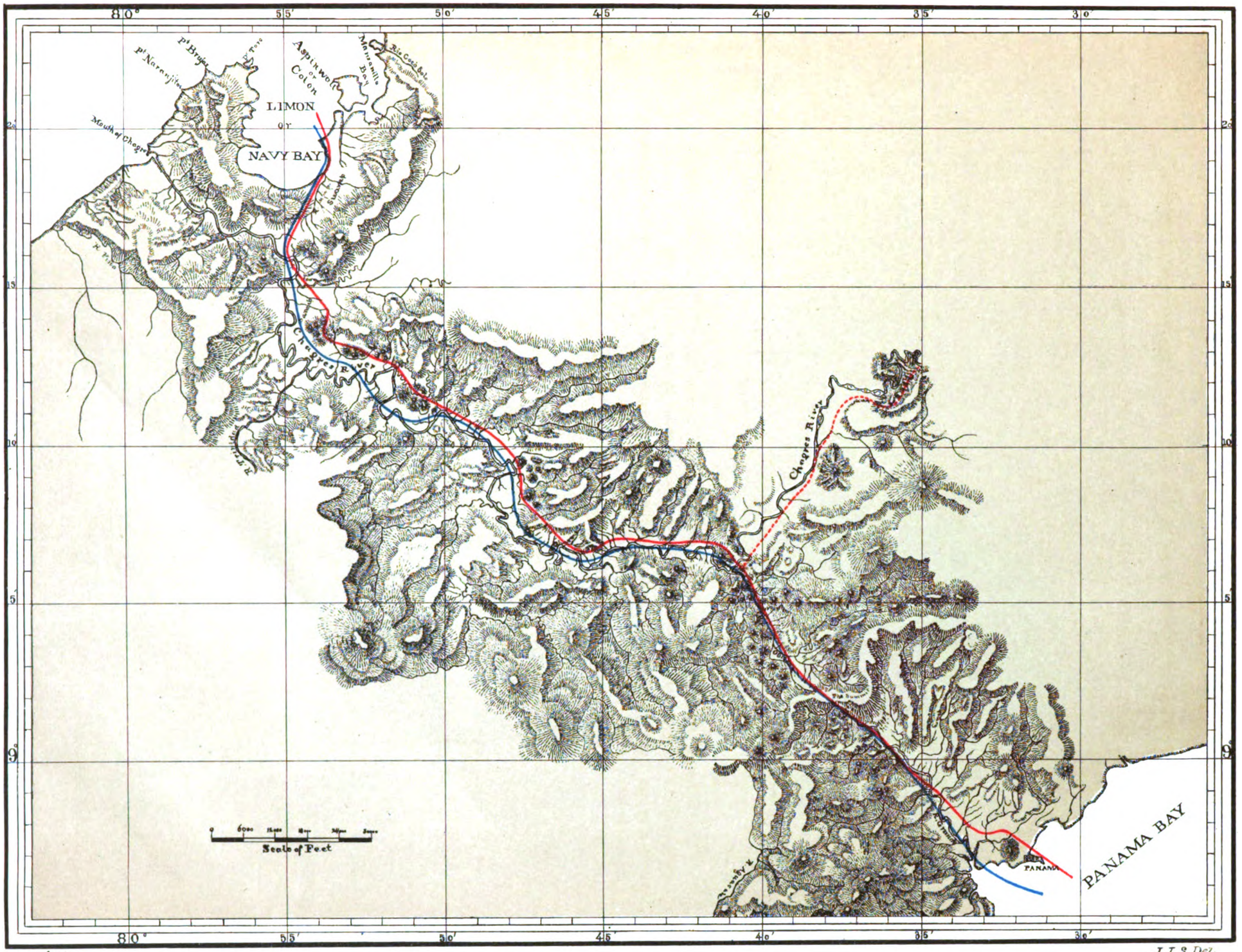

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J. T. S. Del.

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7. The necessity of introducing a viaduct.
8. The unhealthfulness of the country.
9. The objections which apply to all lock-canals.

In addition it may be stated as an objection that its cost will be much increased by the necessity of purchasing, at a high figure, the right of way from the Panama Railroad Company.

M. DE LESSEPS' SCHEME: A CANAL AT THE SEA-LEVEL.

The canal proposed follows the general course of that already described but is located nearer to the river beds. The scheme involves an open cut through the Isthmus at a uniform depth of 28 feet below the low-tide levels of the oceans. A tide-lock is necessary at the Pacific terminus. The length of the canal by the line followed is 45.5 miles. The dimensions for the wet section are, for the main portion of the line—

	Feet.
Width at bottom	72
Width at water-line	164
Depth	28

In the heavy cutting through the dividing ridge, or the Culebra cut, the dimensions are somewhat different, being—

	Feet.
Width at bottom	79
Width at water-line	85.5
Depth	29.4

A technical commission, appointed by M. Lesseps to examine the definite work for the construction of the canal, adopted the figures contained in the following table, representing the quantities of excavation and a general estimate of cost. The commission consisted of the following-named engineers, and they agreed to estimate the cost of the work at the prices fixed by the Paris Congress: G. M. Totten, J. Dirks, E. Boutan, W. W. Wright, V. Dauzats, Pedro J. Sosa, Alejandro Ortega, A. Couvreaux, fils, Gaston Blanchet.

EXCAVATIONS.

Sections.	Under water.			Above water.		
	Earth.	Hard soil capable of being dredged.	Hard rocks.	Earth.	Rocks of mean hardness.	Hard rocks.
	Cubic meters.	*Cubic meters.*	*Cubic meters.*	*Cubic meters.*	*Cubic meters.*	*Cubic meters.*
Atlantic section	9,330,000	300,000	3,775,000	23,710,000	825,000	3,060,000
Culebra section			2,634,000	2,167,000		23,199,000
Pacific section	2,675,000		377,000	1,473,000		1,475,000
Total	12,005,000	300,000	6,786,000	27,350,000	825,000	27,734,000

Grand total, 75,000,000 cubic meters.

GENERAL ESTIMATE OF COST.

1st. Excavations (sidings included):

(*a*) Excavations above water:

	Francs.
Earth, 27,350,000 cubic meters, at 2.50 francs	68,760,000
Rocks of mean hardness, 825,000 cubic meters, at 7.00 francs	5,775,000
Hard rocks, 27,734,000 cubic meters, at 12.00 francs	332,808,000
Excavations of rocks where pumping is necessary, 6,409,000 cubic meters, at 18.00 francs	115,362,000

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(*b*) Dredging and excavations under water:

	Francs.
Mud and alluvial soil, 12,005,000 cubic meters, at 2.50 francs	30,500,000
Hard soil capable of being dredged, 300,000 cubic meters, at 12.00 francs	3,600,000
Excavation of rocks under water, 377,000 cubic meters, at 35.00 francs	13,195,000
	570,000,000
2d. Dam of Gamboa: length, 1,600 meters, maximum height, 40 meters	100,000,000
3d. Channels for the regulated flow of the Chagres, and for the Obispo and Trinidad Rivers	75,000,000
4th. Tide lock on the Pacific side	12,000,000
5th. Breakwater in the Bay of Limon	10,000,000
	767,000,000
6th. Add for contingencies	76,000,000
	843,000,000
Or, at 5 francs to the dollar	$168,600,000

The cost of administration; the cost of the concession; interest on dormant capital; the stockholders guaranteed premium during the construction of the work; and, finally, the amount to be paid in buying out the Panama Railroad Company must all be added to the above estimate, and will swell its total by many millions of dollars.

The advocates of this scheme claim—

1. That it is the shortest of the practicable routes.
2. That it will cost less than any other canal offering the same advantages.
3. That it can be constructed in less time than any other canal.
4. That the cost of maintenance will be less.
5. That it will be more easily preserved from obstructions.
6. That it has ports at its termini.
7. That it runs through an inhabited district.
8. That there is already a railroad along the entire route of the canal.
9. That a sea-level canal is the only kind that will satisfy the demands of commerce.

To these claims it is objected—

1. That it is not the shortest of the practicable routes. A sea-level canal across San Blas would be at least 15 miles shorter.

2. It will cost more to construct a sea-level canal than one with a few locks, and the advantages claimed for it of having only a tide-lock amount to nothing, as that one lock limits as effectually, and in the same degree, the number of ships that could pass through the canal as would five or six locks, or even more.

3. Many very able engineers doubt the possibility of its construction without unlimited funds and time. The natural difficulties to be overcome are of the most gigantic proportions. The grand difficulty is to provide for the surface drainage. The average rainfall amounts to over 12 feet. This is not distributed throughout the year, but is precipitated within two periods, or rainy seasons, aggregating at most seven months. During a single rain-storm 6¾ inches have fallen in six hours. The floods in consequence are excessive, and in the Chagres River often rise 30 or 40 feet in a few hours. As the canal is to be at the sea-level, it would be the ultimate drain of all the waters in the basins of the Chagres and the Rio Grande. At the point where the canal crosses the Chagres River it is, in the dry season, a small stream about 250 feet wide and 2 feet deep, but during a heavy flood the width becomes 1,500 feet, the depth over 40 feet, and the volume of water passing this point is fully 160,000 cubic feet per second. The bed of the river is here 42 feet above the sea-level, which is to be the level of the canal. The top of a 40-foot flood would then be 82 feet above the level of the canal where it crosses the Chagres, or, making allowance for the decrease

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due to the velocity of the water as it approached the precipice and for the head of water above the ocean level after falling, 78 feet. This immense volume of water would fall through this height into the canal unless the river is diverted from seeking its present bed. The flood waters of the Chagres are not only heavily charged with detritus, but with an immense amount of *débris* as well. Houses, trees, masses of vegetation, rocks, and stones are borne on its floods, and in a freshet which occurred in the winter of 1879–'80 an iron tank, 17 feet above the level of the railroad track, was carried away. In order to divert these floods from the canal, it is proposed to build a dam across the river at a point above where the canal crosses the Chagres, and then lead the waters from above the dam by an entirely new channel to the sea. This undertaking is almost equal to the rest of the work. The dimensions of the proposed dam are: height 132 feet, and length 5,248 feet, or nearly a mile. As yet no foundation has been found upon which to rest such a dam. It is estimated that the basin resulting from the construction of the dam will hold 1,300,000,000 cubic yards of water, a volume equal to that of the greatest flood that has been recorded. It is not, however, as much as two floods would bring down; and in the contingency of two floods occurring within a short interval, the basin would overflow into the canal and cause its destruction. To emphasize the necessity of providing for surface drainage, and prevent its being taken into a canal, Admiral Ammen quotes the following, in a paper before the American Geographical Society, from the Bulletin Decadaire of the Suez Canal, of June 12, 1878:

"On the part of the canal in the vicinity of Suez, on the 25th of October last, a violent storm produced a sudden and immense temporary torrent, which, precipitating itself from the mountain of Attaka, fell into the canal, carrying with it a very large mass of solid material. This deposit, thanks to the activity of our employés, was dredged very rapidly, so that navigation was not retarded a single day; but this unexpected dredging has added 30,000 francs to the expenses of the canal."

With reference to this, Admiral Ammen states that "the mean annual rainfall at Cairo, less than 100 miles from this locality, is 1.3 inches. At Aspinwall the mean annual rainfall is 124.25 inches. During the month of November, 1870, there was a rainfall of 32.5 inches, twenty-five times the mean annual rainfall at Cairo. If the rainfall, as at Aspinwall, were the normal condition along the line of the Suez Canal, it seems altogether probable, from the damage and expenses caused by one shower, as quoted above, it would be a matter for serious consideration whether it would not be economy to lock up sufficiently high at least to avoid the effects of surface drainage."

4. Its cost of maintenance must necessarily be very great on account of controlling such an extensive system of artificial drainage under the most unfavorable circumstances.

5. The harbor on the Atlantic side, in its present state, is exposed to the severe northers which blow occasionally during the winter months, but suitable protection may be afforded by the construction of a breakwater.

6. The cost of excavation will be much increased on account of the distance materials will have to be lifted out of the cut, and on account of the distance they will have to be carried before a final deposit. The eminent American engineer, Mr. Trautwine, estimates that when excavation costs 19 cents a cubic yard, when deposited within 25 feet, it will, if carried one mile in carts, cost 57.09 cents per cubic yard, and if carried two miles will cost 95.57 cents per cubic yard. This rapid increase in the ratio of cost shows how important it is to have a place of deposit close at hand. In ordinary works much of the excavated material can be used to make fills or embankments in its immediate vicinity, but in the case of a sea-level canal it must be placed where it will not be washed back again, and this will involve its transportation over long distances.

"Every cubic meter of earth taken from the summit must be hauled away to some distant point for deposit, since there is none in or about the narrow pass, and if there were such a place the torrents of the rainy season would sweep the material back into the cut. Soon after leaving the coast, upon either side, the mass of cutting falls much below the country level, and the earth or rock must be lifted to that level to be then hauled a distance, or it must be taken along the line of excavation to the sea. This evil of long carriage grows greater as the cuts from either side penetrate the elevated regions, and precisely where the vast mass of excavation is to be done. As the cut reaches the rock formation, it will lie below an extended drainage area hundreds of feet above. Must it not be anticipated that subterranean water-channels will be cut, channels carrying water coming from the heights above, and therefore under heavy pressure? * * * Under the condi-

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tions thus briefly sketched, and remembering that a cubic meter is more than one and a quarter cubic yards, can there be any doubt of the expensive character of the work? Will any experienced man believe that any 27,000,000 cubic meters of excavation can be taken out and hauled to a distant dump at the rate of 37 cents per cubic yard? Can he believe that hard rock can be excavated, raised to the surface, and hauled away for $1.76 per cubic yard, or that it can be excavated below the sea-level, pumping included, and carried off for $2.65 per cubic yard?"*

7. It is true that the line passes through what may be called an inhabited country, but the resources of the country and its inhabitants are of but little value in this case. The climatic conditions are as bad as can be found on any portion of the Isthmus. All provisions required for the sustenance of the construction party will have to be imported, as will also materials for constructing the work, as suitable materials for hydraulic works are not to be found in the country. The railroad ties and telegraph poles of the existing road are imported.

In stating the probable cost of a canal through Nicaragua the United States Canal Commission rejected the 25 per cent. usually allowed by engineers to cover contingencies, as insufficient, and applied 100 per cent. instead. Treating the estimated cost of the Panama sea-level canal in this manner, the probable cost amounts to $306,400,000.

The objection of the calms of Panama Bay of course apply to this scheme. A full discussion of this subject will be found in the testimony of Lieut. Frederick Collins, U. S. N., before the Select Committee of the House of Representatives on the Interoceanic Canal. His statement of the case will be found in Appendix B.

NICARAGUA ROUTE.

This route lies between the port of Greytown, or San Juan del Norte, on the Atlantic, and the roadstead of Brito, on the Pacific.

The scheme is that of a lock canal, having Lake Nicaragua for its summit-level. The elevation of the surface of the lake above the level of the oceans is 107.63 feet. From Greytown the canal will follow an almost straight line to the San Juan River, striking it at a point about six miles below the mouth of the San Carlos; thence it will be constructed on the left bank of the San Juan until reaching a short distance above the mouth of the San Carlos, where slackwater navigation commences. This river navigation is secured by means of a dam placed across the San Juan, above the mouth of the San Carlos, where an excellent site for it exists. The dam will be 2,000 feet long and 49 feet in height above the surface of the river, or 59 feet above the river-bed. It is high enough to raise the surface of the lake 3 feet, making the summit-level 110.63 feet. By means of this dam, slackwater navigation is secured in the San Juan for more than 63 miles; the amount of excavation in the river-bed and in the marginal waters of the lake is very much reduced; the limits of the lake are extended, and the amount of excavation through the dividing ridge, between the lake and the Pacific, is very much diminished.

The summit-level thus obtained will be 130 miles long. Of this distance less than 10 miles are canalized, leaving more than 120 miles that can be traversed at a high rate of speed.

After crossing the lake the route lies in the valley of the Lajas, on the lake slope, and in the valley of the Rio Grande, on the Pacific slope, terminating at the roadstead of Brito. The length of this section is 17.27 miles, of which distance more than 8 miles belong to the summit-level. The deepest cut through the divide between the lake and the Pacific is 40 feet to the level of the canal.

To ascend to the summit-level from the Pacific, one tide-lock and six lift-locks will be used; on the Atlantic slope it is possible to locate locks with a greater lift, so that only five will be introduced. The dimensions of the wet section of the canal are—

	Feet.
Width at bottom	72
Width at surface	106, 128, and 165
Depth	26
Length of locks	600
Width of locks	70

* It is not possible to present the name of the writer of the article from which these extracts are taken. They appeared in a letter to the New York World during the latter part of February, 1880. The article bears no signature.

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The total length of the route and the lengths of its sections are as follows:

	Miles.
Canal, from Greytown to dam	35.90
River navigation	63.90
Lake navigation	56.50
Canal, from lake to Pacific	17.27
Total	173.57

Of which distance but 53.17 miles is actual canal.

The route and scheme adopted by the United States expedition of 1873 differ from the above in several particulars. These changes and the reasons for making them will appear in the following extracts from the report of a survey made by Civil Engineer A. G. Menocal, U. S. N., in 1880, by order of the Navy Department:

"It has been stated in the official reports of the surveys made by the United States expeditions of 1872–'73, and by other authorities, that two lines had been located for the canal between Lake Nicaragua and the Pacific; one extending from the mouth of the river Lajas, on the lake, to the port of Brito; the other from the mouth of the river Del Medio to the same terminal point on the Pacific.

"The portion where there is a difference in location is between the lake and the first lock on the Pacific slope, or, in other words, in that portion of the canal where the level of the lake is to be extended westerly. From Lock No. 1 to Brito they have a location in common. The deepest cuttings required to reach the proposed level of the canal are: For the Lajas line, 43¾ feet; for the river Del Medio route, 134 feet, the length of the respective lines being 17.27 miles for the former and 16.33 miles for the latter. The estimated cost of the Del Medio route exceeded that of the Lajas by several millions, but after mature consideration, and by reason of better natural surface drainage, so essential to the stability of a work of this kind, built in a country subject to a large rainfall, the river Del Medio route was favored. On this line no water-course of considerable size would be taken into the canal, and as its watershed is quite small no fears were entertained of damages from freshets. On the Lajas route the conditions were dissimilar. The river Grande, a mountain stream of extensive and rapidly inclined watershed and precipitous channel, approaches the canal from the southwest, and turning to the northwest passes, with many sinuosities, through a narrow valley of a width but little greater than required for the canal. The channel of the river has an average width of 60 feet and a depth of from 15 to 20 feet, and in its tortuous course alternately approaches the bases of spurs of a variable elevation projecting from the main hills on either side. Colonel Childs, who, in his plans for a canal by this route, had proposed to receive this stream into the canal by means of a waste weir, estimated its maximum flow, calculated from the highest water marks on the banks and its mean sectional area and descent, at 5,670 cubic feet per second. I have been able to obtain, as a result of my own observations, and from information furnished by old residents in the vicinity, what may be regarded reliable data as to highest water marks, which, with the mean descent of the river for several miles and its average water prism, show that the maximum flow may be as great as 10,000 cubic feet per second. It is quite certain that this stream seldom rises to the height assumed, and since its watershed is very abrupt it remains but a few hours at the high-water marks pointed out to me. But so large a volume of water could not be received into the canal at a time when least needed as a feeder, even under the most favorable conditions of flow, without danger to navigation and to the stability of the work. This was the greatest objection to this route, and to obviate it the preference was given, not without reluctance, to the river Del Medio route.

"Partial examinations of this region, conducted during visits to Nicaragua, subsequent to the official surveys, had greatly added to my former knowledge of the territory traversed by the canal. I was thus aware that important changes in the original location could be introduced, but there was required an instrumental examination in order to determine the measure of the benefits to be derived therefrom. My last survey on this portion of the canal route was for the special purpose of ascertaining the practicability of turning the river Grande into the lake, thereby leaving the narrow valley now occupied by its channel across the divide free for the construction of

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the canal. With this purpose in view the survey was begun at a well-known station and bench-mark of the survey of 1872, and carried along the bed of the river Grande to its confluence with the river Cascabel, its main tributary. Special care was taken in noting all desirable sites for dams. Ascending the stream the first was found at 'El Carmen,' a point 3,000 feet by the river from the line of the canal. At this point the bed of the stream is 108.48 feet and the highest water mark 124.39 feet above mean sea-level. From the site of the proposed dam a transit and level line was run in a southwesterly direction, crossing the divide between the Grande and Lajas, with an elevation of 178.38 feet. The line then fell into the brook 'Comalcagun,' an affluent of the river Juan Davila, the main branch of the Lajas. Following the brook across the extensive valley of Iocotes, the Juan Davila was reached at a distance of 3.88 miles from the bank of the river Grande, and at an elevation of 128.27 feet.

"To turn the river Grande into the Juan Davila, and through the latter and the Lajas into the lake, a dam 39.67 feet high will be required, this height being the aggregate of the difference of level between the river Grande and Juan Davila and the necessary fall of the artificial channel, as follows:

	Feet.	Feet.
Elevation of bottom of river Grande	110.87	.....
Elevation of high-water mark, river Grande	127.37	16.50
Elevation of water in Juan Davila	128.27	.90
Elevation of high water in Juan Davila	140.73	12.46
Fall of artificial channel at 2.53 feet per mile		9.81
Height of dam above bottom of river Grande		39.67

"The required height of the dam being established, it was observed that in times of high floods the water in the artificial channel would inundate to the depth of 2 or 3 feet the valley of Jobito, and possibly escape into the river through some pass between the hills. Another site for a dam was in consequence fixed some distance above the first, and the line for the artificial channel was relocated over higher ground. The profile represents the corrected line and elevation of dam resulting therefrom. The proposed channel is 75 feet wide at the bottom, 15 feet deep, has slopes of 1 to 1 and 2 to 1, respectively, for earth and rock excavation, and with the proposed fall of 2.53 feet per mile will have a discharging capacity of 10,273 cubic feet per second, or more than the largest estimated flood of the river Grande. The elevation of the water of the Juan Davila at its confluence with the artificial channel is 128.27 feet in the dry season and 140.73 feet at high floods, or 18 and 30 feet, respectively, above high lake; and the distance from the river being about 6 miles, there will be a fall of from 3 to 6 feet per mile, which in the broad channels of the Juan Davila and Lajas need occasion no apprehension of the waters rising upwards of 9 feet above highest recorded floods backing into the Grande and flowing over the dam.

"Having established the practicability of diverting the river Grande, I directed my attention to a careful examination of the narrow valley occupied by the river, having in view a relocation of the canal route so as to utilize the channel of the river wherever practicable, avoid the hills on both sides, and enlarge the radii of the curves as much as the topography of the country would permit. The relocation made, as shown by the map and profile, is more favorable than was expected, and the estimated cost of the work, as given below, will show the large amount saved by the substitution of this route for that of the river Del Medio, while the drainage of the latter is in no respects better than that of the former.

"In computing the amount of excavation required by the new profile, a uniform width of 72 feet at the bottom and a depth of 26 feet, with slopes as before, have been assumed throughout. That being the maximum width adopted for the river Del Medio route, a fair comparison of the relative cost of the two lines can be made, leaving for another place the consideration of the necessary increase of cost resulting from a modification of the dimensions originally recommended, changes that would affect one as well as the other route.

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"The following is the amount of excavation and embankment required by both routes, with their estimated cost:

	Route.		Price.	Estimated cost.	
	Del Medio.	Lajas.		Del Medio.	Lajas.
	Cubic yards.	*Cubic yards.*			
Excavation in rock	2,915,812	1,359,582	$1 50	$4,373,718	$2,039,373
Excavation in rock above prism	7,907,812	2,719,165	1 25	9,884,765	3,398,956
Excavation in earth	6,583,788	7,224,282	35	2,304,326	2,528,498
Embankment	2,247,565	781,051	10	224,757	78,105
Totals				16,787,566	8,044,932
				8,044,932	
Difference				8,742,634	

"For a fair comparison of the two routes, the cost of the dam and artificial channels should be added to the estimated cost of the Lajas line.

ESTIMATED COST OF CUTTING THE ARTIFICIAL CHANNEL.

1,592,434 cubic yards excavation in earth, at 35 cents	$557,352
403,649 cubic yards excavation in rock, at $1.25	504,561
Total	1,061,913
Estimated cost of dam across river Grande	140,000
Artificial channel at mouth of river Lajas	488,000
Total	1,689,913

"Deducting this amount from the difference in the estimated cost above given, we have the total saving (under the same conditions and price for quantity of work) of $7,052,721.

"It will be observed, from an examination of the profile submitted, that the level of the lake has been assumed at 110.63 above mean tide, the height it attained at the end of the rainy season of 1878, and that the different reaches of the canal below the first lock have been located almost altogether in excavation, which is not the case on the Del Medio route; so that there has been an increase of excavation and a proportionate decrease of embankment in that portion of the line. The figures in the estimate for the Del Medio route have not, however, been changed.

"The height assumed for the summit-level, 110.63 feet, an increase of 3 feet to that proposed in the original plans, will bring a decrease of 2,380,980 cubic yards of dredging and blasting under water in the lake and river, which, at the prices adopted, amount to $1,356,900.

"In the original plan for slackwater navigation in the river San Juan, it was recommended to build four dams, varying in height from 21 to 32 feet above the bottom of the river, and three short canals with locks to connect the different reaches. An excellent site has been found above the river San Carlos, where a single dam of over 2,000 feet in length, and 59 feet in height above the bottom of the river, or 49 feet above the surface of the water, will secure an uninterrupted river navigation a distance of more than 63 miles, or a continuous summit-level of more than 130 miles between the first locks on either side. The advantages to be gained by this modification cannot be overestimated, not only on account of reduced cost, but, what is of very great importance, the large increase in depth and width of channel gained in the whole river navigation.

"The estimated cost of the four dams proposed in the original plans, amounts, in the aggregate, to $1,543,526, and that of the short canals, to $1,056,922. Supposing the single dam now recommended to cost as much as the other four, there will yet result a saving of over $1,000,000, the cost of the small canals, and $283,000, the cost of the designed diversion of the river San Carlos, now uncalled for.

"When the canal line extending from below the river San Carlos to Greytown was located by

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the surveying expedition of 1873, but little information concerning the topography of the country beyond the valley in close proximity to the river could be obtained. The rainy season was at hand, and the *personnel* of the expedition was too limited to admit of detaching from the main work of location for the purpose of exploring an entirely new region, in which the chances of finding a more favorable location than was known to exist along the left bank of the river were very remote. More than one attempt was made in that direction, but without definite results. The line was, in consequence, carefully surveyed as delineated in the plans accompanying the official reports, and whatever is there shown may be relied upon as a truthful representation of the natural conditions, and what was proposed has been regarded as entirely feasible. Some time after the completion of that work, I had occasion to make a complete survey of the river San Juanillo and lower valley of the San Juan, a region scarcely known even by the natives of the country. The information then obtained, sustained by subsequent explorations, indicated the possibility of finding a far more advantageous location for the canal route, so that diverging the line from the vicinity of the San Juan, at a point 7 miles below the mouth of the San Carlos, it would reach the harbor of Greytown by an almost straight line. It was expected by the new location to save several miles of canal, and, what is of greater importance, to dispense with the sharp curves made necessary by the abrupt bends of the river and high spurs projecting from the main hills in the interior to the water's edge, and relieve the canal from the drainage of many square miles of watershed that had to be provided for by the original plan.

"I regret very much my inability to present now the results of an instrumental examination, with plans and profiles showing a line of actual location on which to base an estimate of cost; I am able to affirm, however, that the proposed change is entirely practicable. A personal inspection of that region, conducted with the assistance of the pocket compass and aneroid, shows that the canal line can be taken from the left bank of the San Juan, at a point 6 miles below the San Carlos dam, and located over very favorable ground in an almost straight line to Greytown. The distance saved will be about 7.4 miles, as compared with the first location. Deducting from this distance the needed increase in length of canal on account of change of site for dam, we have the total as the distance saved, 6 miles.

"I can safely state that the new location will be found more favorable than the first; but assuming the cost of excavation and embankment per mile to be the same for both lines, we have an economy in construction of $1,917,336.

"The aggregate saving by the several changes proposed is as follows:

By Lajas route	$7,052,721
Dredging and blasting in lake and river	1,356,900
Short canal in river San Juan	1,056,922
Six miles of canal between the river and Greytown	1,917,336
Which deduct from original estimate	11,383,879
Total	52,577,718
We have, estimated cost of the work, on the same basis	41,193,839"

This is the engineer's estimate without any allowance for contingencies. Applying the allowance of 100 per cent. adopted by the United States Canal Commission, the extreme limit of possible cost will be $82,387,678, or $10,000,000 less than the cost of the Suez Canal. It is not likely though that this extreme limit will be reached, as the engineer's estimate is based upon a detailed survey of the line; and the prices which have been assumed for materials and construction are regarded as ample. It is important to remember that, as the line is one of actual location, any changes which may be suggested by a fuller knowledge of the topography of the country will always tend to a reduction of the original estimates.

The principal objections raised against this route are:

1. Its length.
2. That it requires locks.
3. Its want of harbors.
4. That it lies in a volcanic region.

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These objections are answered as follows:

1. The length of the canal proper is only 8 miles greater than that required on the Panama route. If two canals differed in their conditions only in the element of length, the shorter would of course be preferred, but if they differ in other respects, it is possible that the longer canal would have the preference. This is actually the case between Panama and Nicaragua. Although a vessel would be a longer time in transit, from ocean to ocean, via Nicaragua than via Panama, yet she would, if a sailing vessel, make the voyage from New York to San Francisco and back in nineteen days' less time than if required to go via Panama; and if a steamer, in five days' less time. This is fully explained in the statement of Lieutenant Collins already referred to.

2. That it requires locks. If an artificial strait could be cut through the Isthmus at any point and maintained, it would be desirable; but any sea-level canal through the Isthmus must be provided with at least a tide-lock, and this, as already shown, limits the capacity of the canal to receive or discharge vessels as effectually as if other locks intervened. Locks are objected to as expensive to maintain, as liable to be damaged and interrupt the traffic of the canal, and on account of the length of time required to pass vessels through them.

The most valuable experience relating to locks of large dimensions comes from Canada and the United States; no other countries in the world operate them on such a grand scale. It is proper, then, to rely upon the opinions of engineers who have a knowledge of such extensive hydraulic works. Mr. Gardner exhibited a profile of the Welland Canal improvement, in the discussion before the American Geographical Society, and said:

"This represents a canal 27¼ miles long. You will observe that there is a perfect staircase of locks to carry vessels of 2,000 tons, and the total lockage by this staircase is 326¾ feet, or three times as high as from the Atlantic to the summit-level of the proposed Nicaragua Canal. These locks are 240 by 40 feet, with a depth of 14 feet. The total height of the lockage between the lake and Montreal is about 550 feet. The Canadians built their first ship-canals in 1829, and, after about twenty years' experience with the system, were so well satisfied that they commenced improving and enlarging them, and they have expended about $30,000,000 in this work of enlarging these canals so as to make them practicable for 2,000-ton vessels. The Canadian engineers have more experience than any others with long ship-canals, and demonstrate their success most practically by the enterprise with which they are extending and enlarging their serviceability. The total expenditure of Canada on this long ship-canal route, when it shall have been completed, will be over $54,000,000. * * * But here this lockage in a single place, within a distance of 7 miles, is three times as great as that required on the Nicaragua Canal. The locks are not as large as it is proposed those shall be, but they are large enough to carry 2,000-ton vessels, and these vessels succeed each other rapidly, one right after another. Through the old Welland Canal they could put through 4,400 vessels in a single year, but through the new system 9,000."

In the discussion before the American Society of Civil Engineers, the president of that society, Mr. Ashbel Welch, said:

"My present object is to point out how a ship-canal lock of the most extreme dimensions, and of 30 feet lift, can be made, into and out of which ships of the largest size can be hauled quickly, and in which they can be held and handled safely, and all the operations of the lock performed surely and rapidly by a steam-engine on the wall.

"This mighty agent in its matured state, so powerful, so controllable, so instantaneously and so exactly obedient to human command, can, with suitable appliances, which I propose to point out, be made to perform all the haulings and holdings of the ships, and all the opening and shutting of the gates and valves, safely, certainly, and quickly. Water-power cannot so well be applied directly, for its changes are not quick enough, but it may be applied through hydraulic engines with great advantage. * * *

"It appears from the advice they have given, that some of the most eminent engineers of the world have not thought of this plan, or, at any rate, have not thought it out, and that for want of considering what can be done, and knowing what has been successfully done already, they, as well as most persons interested in navigation, including naval officers, consider locks for ship-canals absolutely inadmissible. I repeat what I have already said on more than one occasion, that if locks for ships could be operated only in the old way, I would no more build one than attempt

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to row the Great Eastern across the Atlantic by human hands. Knowing only the old way, those engineers were right in advising a level canal from the Atlantic to the Pacific, notwithstanding its enormous cost, its unavoidable narrowness involving great delay and risk, its exposure to floods only imperfectly diverted, and all the dangers and expenses incident to deep cuts. * * * I have calculated for a lift of 30 feet. Probably that is as high as the ground will permit any lock to be made. I should not hesitate to go higher than that if the situation permitted.

"When there is plenty of water, or when water-saving basins are used for the locks of large lift, there is no necessity for the traditional Procrustean rule of making the locks of uniform lift, whether that fits the ground or not. Mr. Douglass, already mentioned, made locks of 33 feet lift which worked easily, safely, and well for a quarter of a century. They were emptied in two minutes. The higher the lift the less the cost of construction and operation, and the less the detention per foot lift."

Mr. Welch proposes to control the movements of a vessel entering and leaving a lock by a steam "lock-operator" on the lock-wall, where it has a fixed base of operation.

"All the processes are performed by a single expert, who, from his elevated and sheltered position, does everything, and has every lever within his reach without changing his position or turning his head.

"This is not a mere theory or untried project, but I devised it many years ago, and put it in operation eleven years ago, and it has been in successful operation ever since. True, it is on a much smaller scale; but, on the other hand, it is not on locks best adapted to the purpose, which a ship-canal lock can and should be, and the apparatus is so simple that it can be applied with ease and certainty on any scale.

"The steam 'lock-operator,' as I have christened it, removes all the objections to locks, except the cost of construction and of operation; and it is a question in each case that arises whether more than that cost is saved in some other way; and it is a question in each case whether more time is saved in some other way than is lost by locks.

"Large ships passing a lock should be held firmly in every direction, and never allowed to touch the walls or gates. They should be hauled in slowly; out, as rapidly as the stationary power will move them. Their own steam should not be used except, perhaps, in going out, and their rudders should not be relied on, nor their own crews, except mainly to hook on the wire-rope lines."

Mr. Welch estimates the time required to pass a vessel weighing 40,000,000 pounds—10,000,000 pounds more than the displacement of the City of Rome—to be as follows:

	Minutes.
To hook on the hauling and breast lines	1.0
To give velocity of 3 feet per second in 135 feet	1.5
To move 540 feet at 3 feet per second	3.0
To stop in 135 feet	1.5
To shut the lower gates	1.0
To fill the lock safely (outside calculation)	6.0
To open the upper gates	1.0
To overcome the inertia and move 810 feet	5.5
Total	20.5

"Probably in almost every location where water is to be had a better ship-canal can be made with a few locks, and at a far less cost, than a sea-level canal. A small part of the money saved by the locks will in most cases make a broad and deep channel, where ships can go safely and rapidly, and pass each other anywhere without delay, instead of narrow, deep cuts, commonly dangerous, and always expensive where ships must move slowly, and commonly wait to pass each other.

"The question must be decided in each case whether the very large amount required for the construction and operation of a lock will save a larger amount in some other way, and whether the half-hour's delay at each lock will save a greater delay in some other way.

"The plan I have presented of the construction and operation of a ship-canal lock is so simple,

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and its practicability so evident, your mental exclamations have probably so often been, 'Why, of course,' that I feel like apologizing for taking up your time in laying it before you. And yet, though so plain when once presented, eminent engineers have failed to see it."

The Saint Mary's Falls Canal, near the village of Sault Ste. Marie, Mich., on the outlet of Lake Superior, has the largest lock in the world. The chamber of this lock is 515 feet long, 80 feet wide, and has a lift of 18 feet. Near the gates the width of the lock-chamber is reduced to 60 feet in order to diminish the size of the gates. The construction of this lock has been rendered necessary by the increase in the business of the canal and of the size of vessels using it. In the original canal the difference of elevation was overcome by two combined locks, each 350 feet long, 70 feet wide, and with a lift of 9 feet. The gates were opened by a line and closed by a boom; manual labor being applied through a capstan on the lock-wall. This canal was constructed in 1855, and, even with such primitive methods for operating the locks, has proved to be a very successful one. Thirty-seven vessels have passed through the locks in twenty-two lockages in twenty-two hours. General G. Weitzel, U. S. A. Corps of Engineers, in charge of the improvement of this canal, says:

"I expect to be able to pass a single vessel through the new lock at Saint Mary's Falls Canal, when everything is in good working order, in eleven minutes, as follows, viz:

	Minutes.
Entering lock-chamber	1½
Closing gates	1
Filling lock	6
Opening gates	1
Leaving lock-chamber	1½
Total	11

"To pass the Ville de Paris through a lock of 12 feet lift with modern improvements would require about eight minutes."

The probable time of transit through the Nicaragua Canal is stated by Capt. S. L. Phelps, chairman of the executive committee, Interoceanic Canal Society, to be as follows:

	Hours.
Passage of 51½ miles of canal, at 4 miles per hour	13
120 miles of river and lake navigation, at 10 miles	12
Twelve locks, at fifteen minutes each	3
Deductions, etc	8
Total time	36

If the slopes of the water prism of the Nicaragua Canal are protected by suitable covering a higher rate of speed than 4 miles an hour could be maintained, as vessels steam through the Caledonian Canal, which has a smaller wet section, at as high a rate as 11 miles per hour. The proposed dam across the San Juan River will increase the depth and width of the river channel, which, having easy curves, will permit a very high rate of speed.

3. The next objection to be answered is the want of harbors. No matter how attractive the other features of a route may be, if suitable protection cannot be afforded at the entrances to the canal, the project by such a route would be abandoned. The great desideratum for each terminus of a canal route is a spacious harbor affording protection to the entrance of the canal and to the vessels awaiting transit. It has already been pointed out that the isthmian routes possessing the best terminal ports have the worst internal features; the reverse is true regarding Nicaragua. If such harbors as are desirable do not exist, the questions come up, can they be made? or, if not, can the entrances be properly protected, and can ports be found near enough to the termini from which vessels can be dispatched to enter the canal at any assigned time? As far as they relate to Nicaragua, these questions seem to be satisfactorily settled. The plans proposed for the restoration of Greytown Harbor and the protection of the Pacific terminus of the canal at Brito, have been before the most eminent engineers of the world, and all who have studied them regard the means proposed as capable of accomplishing the end in view.

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With reference to the harbor at Greytown, Captain Lull says:* "The river San Juan discharges its waters through two mouths, the Colorado and the San Juan. The Colorado discharges at the low stage 99 per cent. of the river flow. Its current is opposed directly to the sea, produced by the prevailing trade-winds, forming an ugly bar off its mouth. The Lower San Juan empties into the Bay of Greytown, once a magnificent harbor, but now a mere shallow lagoon. Twenty years ago I saw ships of war anchored where now there is scarcely water for a canoe. The material with which it has been so nearly filled up is the silt already spoken of as coming from the San Carlos River, and which is brought down in enormous quantities during the rainy season. A cordon or mole of sand now closes up the entrance of the harbor almost entirely for the greater part of the year, though during freshets it is broken through, sometimes in one place, sometimes at another. The mole extends from the main shore just north of Greytown in a direction about east by north. Twenty years ago the out portion existed in the form of a hook, which was known as Punta Arenas, and, between the point and the mainland, there was a deep channel. This was entirely closed up, a year later, by the waste material from a break farther out during a freshet. The sea caused by the trade-wind comes from a little to the northward of the travel of the outer beach. The river enters the harbor by two mouths, the principal of which empties into that part of the harbor known as Harbor Head, very near the inclosing sand strip. A small opening near this point is always maintained, though constantly shifting its position. During the rainy season, the current being very strong and the sea outside comparatively still, owing to the interruption of the trade-winds, large quantities of silt are carried outside of the mole, the opening in which becomes wide and comparatively deep. As the rains begin to slacken, and the trade-winds to increase at the change of the season, the sea transports the silt to leeward, and generally closes up any opening that may have been made near the old entrance, just as it did on the first occasion referred to. The filling up of the harbor basin has been largely assisted by the luxuriant vegetable growth, more especially of aquatic species. The cordon, owing to its shifting character, affords very little encouragement to the spontaneous growth of vegetation, and no effort whatever is made by the authorities or inhabitants to assist nature in placing her ligatures upon its unstable sands, and thus giving it some degree of permanency.

THE RESTORATION OF THE HARBOR.

"The plan which I proposed for the restoration of the harbor of Greytown is as follows:

"First. To throw a dike across the head of the Lower San Juan, just below the forks, and thus turn all the silt-bearing waters through the Colorado, whose mouth is 18 miles south of Greytown. This, by cutting off the supply of silt, and, what is of greater immediate importance, by cutting off the freshets, and thus preventing the breaking through and waste of the cordon, will make possible the next step, *i. e.*, that of building together the materials of the cordon, as above suggested, by planting mangrove all over its surface, and by adopting the usual methods for protecting its outer face, viz, piling, mattresses, etc., as far as found necessary, the supply of material which could be moved by the sea would soon be exhausted. An entrance must then be opened near its old place, and protected by a breakwater extending some 3,000 feet in a northwest by north direction, or out to the 35-foot curve. The angle formed by the breakwater and the outer beach would no doubt fill up to a certain extent quite rapidly by the moving sands, but by the adoption of the means above indicated, for cutting off the supply of silt and controlling the movement as much as possible of that which now exists, I feel confident that it would cease before passing the end of the breakwater.

"Portions of the basin of the harbor would have to be deepened by dredging. The waters of the canal being free from silt would be admitted to the harbor, which would also receive the drainage of the San Juanillo, a small stream whose waters are also clear. I believe that the plan here given in its merest outline will be effectual in restoring the harbor and making it adequate for the purposes needed, that is, a protected entrance for the canal.

"It was my fortune to serve as navigating officer of one of our cruising ships in the Caribbean during the years 1858, 1859, 1860, during which time this hitherto magnificent harbor was actually

* In his statement to the Select Committee of the House of Representatives on the Interoceanic Canal.

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closed up. The growth of the mole or cordon towards the western beach had been going on gradually for years, but the final catastrophe was precipitated by the breaking through of the beach outside Punta Arenas, at a point where it had been injudiciously cleared of trees that then existed. So sudden was the movement that the United States frigate Savannah, lying at anchor, barely escaped being shut up for good, being towed over the bar by a visiting steamer with considerable difficulty. Under the direction of my then commanding officer, I made several reconnaissances to note the progress of the change. The study which I made at that time, coupled with that during the summer of 1872–'73, determined me in proposing the plan above described. Mr. A. G. Menocal, the chief civil engineer attached to the expedition of 1872–'73, who, at the time, owing to his constant service in the interior, had but little opportunity to examine this particular question, has, during two subsequent visits, studied it quite thoroughly, and finds but little to change in the proposed plan."

If the angle between the breakwater and the beach should fill up "a further extension of the jetty for two or three hundred feet would almost double the area of deposit, and the harbor would be preserved from the shifting sands for a certain number of years. The artificial beach thus formed by the accumulation of sand may be so shaped that it will either be perpendicular to the prevailing winds, or so inclined to them that the sand, instead of moving toward the entrance of the harbor, will be shifted south toward the Colorado, when the harbor may be considered permanently restored."*

IMPROVEMENT OF THE PACIFIC TERMINUS.

"An artificial harbor is proposed to be made at Brito by means of a breakwater and dredging. The present harbor is formed by a steep and rocky hill, about 250 feet high, projecting in a southerly direction for about 1,200 feet from a sandy beach, lying southeasterly for a distance of 2½ miles, and ending at another range of hills terminating abruptly on the coast. At the southern extremity of the first hill a small rocky ledge extends into the sea, and ends at 18 feet depth of water at low tide; and from this ledge the breakwater will commence and extend 1,200 feet southeasterly, ending at 30 feet below low water. A jetty 500 feet long is also proposed in a southerly direction, and nearly perpendicular to the beach, to prevent the shifting of the sand into the harbor and as a better protection from the swell. The dredging will extend from the breakwater to the tide-lock at the entrance into the canal, and from the jetty to the base of the hill, comprising an area of about 67 acres, which is thought sufficient to meet the traffic of the canal, particularly if the proximity of the lake is considered, where vessels can find an ample, safe, and pleasant anchorage; and should an interruption occur in the navigation of the canal, the harbors of Nacascola and San Juan del Sur, from 10 to 12 miles to the south, could accommodate a large number of ships with perfect safety. The material to be excavated in the harbor is, so far as could be ascertained from inspection and borings made at a short distance from the line of the coast, compact sand. The Rio Grande, which now empties into the sea at the base of the hill, is proposed to be diverted by means of an artificial channel, and made to discharge some distance to the southeast of the harbor."†

4. The remaining objection, that the route lies in a volcanic region, seems to be very well disposed of by Mr. Menocal in the discussion of this point before the American Geographical Society. He says, referring to the ruins left by Walker:

"They stand to-day just as he left them, those, at least, which were allowed to remain as ruins. The houses were rebuilt, but the churches were not, and their bare, blackened walls, standing alone and devoid of any support or braces, rise to a height of, I should say, 40 feet. I have examined them very carefully, and did not find a crack in them. Some of the towers were partially blown down then by powder, and look as if they were likely to tumble down at any moment. One, especially, seems threatening to fall with the wind. Yet they stand there as they have stood since 1854. These are 42 miles from the proposed line of the canal. In the town of Rivas, 2½ miles

*Menocal before American Geographical Society. For further information concerning Greytown Harbor, see report of Professor Mitchell, Appendix.

†Report of Civil Engineer A. G. Menocal, U. S. N., to Commander E. P. Lull, commanding Nicaraguan Expedition.

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from the canal, they have many stone houses, and about ten years ago they completed a stone church there which had been building for thirty or forty years—one that would be a noteworthy church anywhere—and it has never received injury from earthquake shocks, nor have the stone houses about it. I had occasion to show to the United States Commissioners dams that had been built surely over one hundred years ago, and are standing to-day, though not for any practical purpose, they have never been repaired, yet manifest no imperfections which can be detected by the closest examination. They were built originally for the purpose of damming up water to be used in the manufacture of indigo, and were abandoned, and have been standing there for a hundred years, perhaps. We saw a gentleman who lived close to the dam near Rivas, and he said it had been there since he was born—he was not less than seventy years old—and before his time, but he could not say how long, as his father never told him when it was built. Yet it is now in the same perfect condition that it was, presumably, when first built, with no cracking, no imperfections, and no leakage; yet it has no apron, and the water has a sheer fall of 15 or 20 feet to its base. Its length is 75 feet.

"In the town of Masaya they have a tank or reservoir in connection with their water-works which stores water to a depth of 20 feet. The thickness of the wall of this tank at the bottom is only 4½ feet, hardly the theoretical thickness required for the best possible construction of such a wall, yet this is built only in the roughest way of rubble work, and though it has been in use four or five years, there is not the slightest sign of any imperfection from weakness, earthquakes, or any other cause."

These references not only show that the locks and dams of the canal will not be affected by earthquakes, but that the country furnishes building materials of a superior quality.

The advantages which the route possesses are:

1. It is in a favorable geographical position, being in the region of the trade winds, and is especially favorable to the United States.

2. A canal constructed here will cost less than half as much as by any other route.

3. It passes through a country rich in resources and already sufficiently developed to subsist the construction force. "The country in the vicinity of the lake cannot be surpassed in the beauty of its scenery. The soil is productive and its pastures abound in excellent cattle. On the west side of the lake the country is thickly populated, and coffee, sugar-cane, indigo, cocoa, corn, rice, and all the tropical fruits are successfully and extensively raised. Valuable woods, both for constructions and cabinet work as well as other materials for constructions, are abundantly found on the mainland as well as on the several large islands in the lake." The population is between 250,000 and 300,000, of which number the majority are located in the vicinity of the lake and between it and the Pacific. There is an abundance of good stone, but it is not suitable for dimension stone. It will answer very well for concrete. There is plenty of limestone, and the kilns now in operation produce an excellent quality of lime suitable for hydraulic works. Bamboo, which would be useful in the works connected with the restoration of Greytown Harbor, can also be obtained in the country.

4. It offers no engineering difficulties that are not easy of solution at a moderate expense. The difficulties to be encountered are such as are met with and overcome in all engineering works of this kind.

5. It is a fresh-water canal and will perform an important office in cleaning the bottoms and boilers of vessels passing through.

6. It offers splendid facilities for dockage and repairs on Lake Nicaragua; and it is not improbable that Paterson's grand scheme of establishing a distributing center for the commerce of the world may find its realization on the shores of Lake Nicaragua.

7. All materials needed for the construction of the canal are close at hand.

8. All plant can be conveyed by water communication already established and for which no royalty is to be paid. Between the lake and the Pacific several passable roads exist, and whatever other roads might be required over this short distance can be readily made at inconsiderable cost.

9. The mean annual rainfall is comparatively small. The lower part of the San Juan Valley has a rainfall of 85 inches, or more, per annum; above the mouth of the San Carlos, 80 inches; and at Virgin Bay, Lake Nicaragua, the rainfall does not, probably, exceed 50 inches. It is impos-

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Profiles of the different routes projected on the same scale for the purpose of comparison.
Vertical scale, 500 feet = 1 inch
Horizontal scale, 20 miles = inch.

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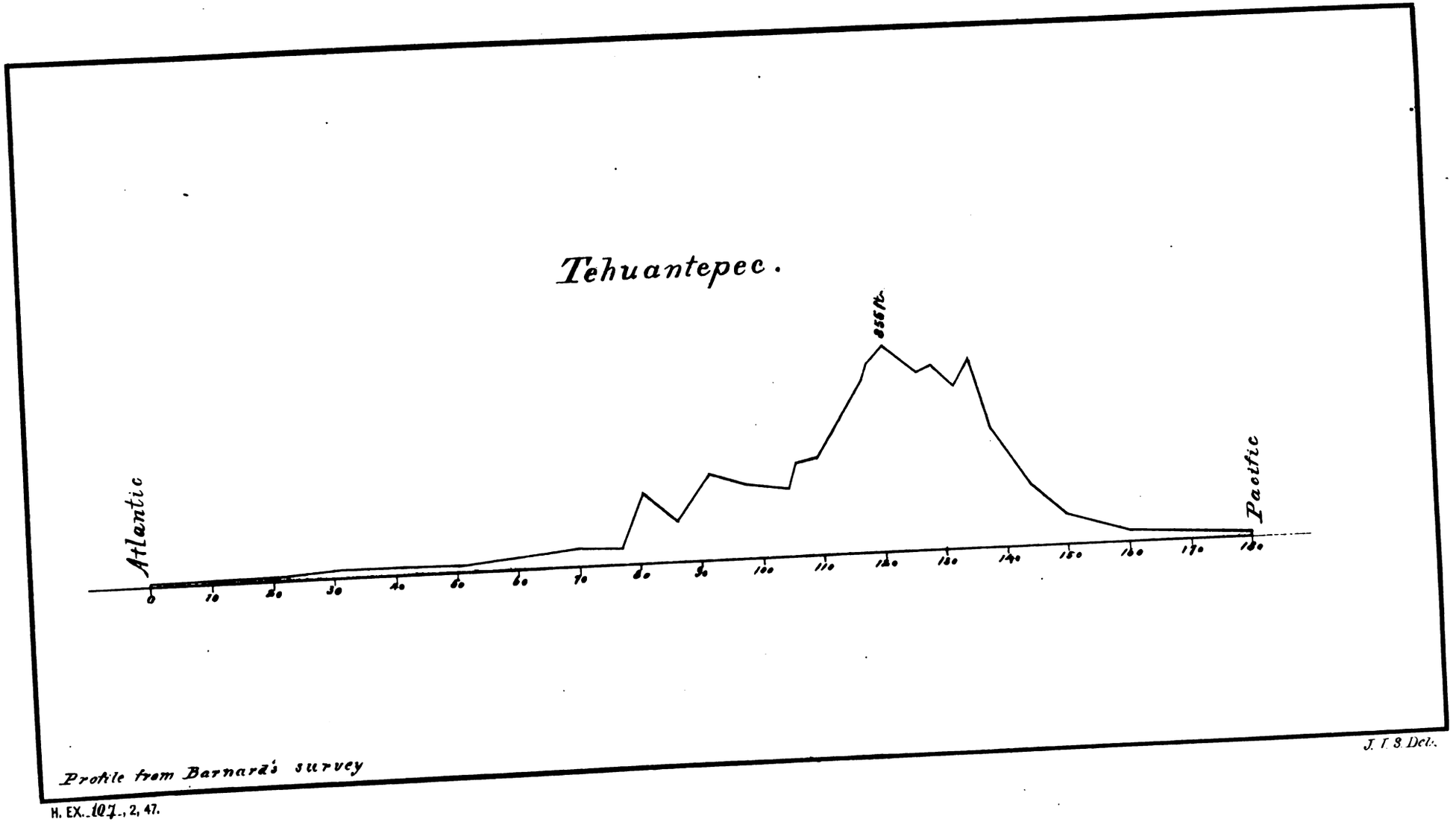

Profile from Barnard's survey

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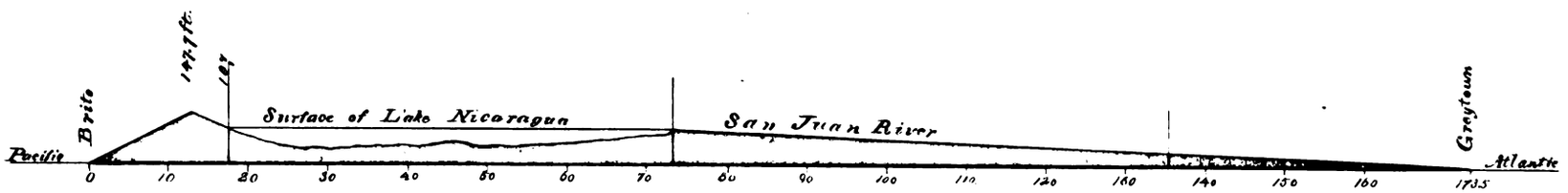
Nicaragua.



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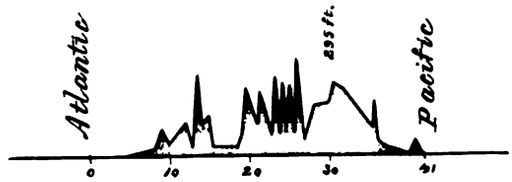
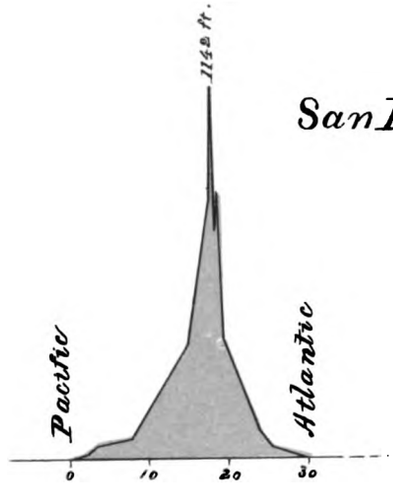
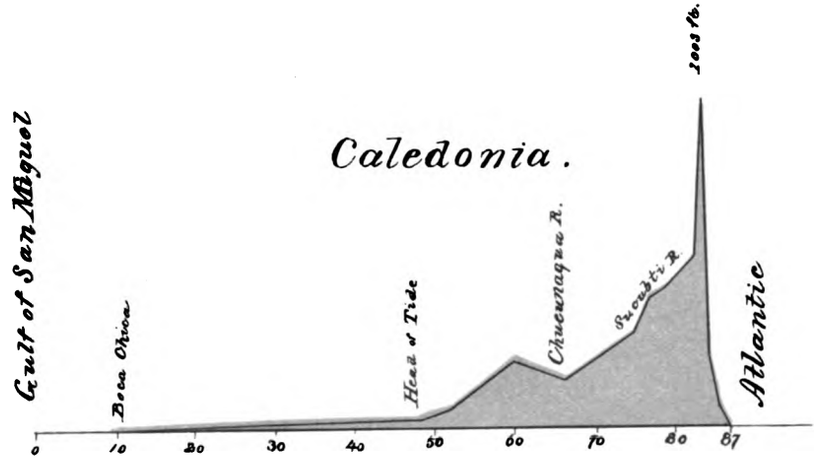
Panama.



San Blas.



Caledonia.



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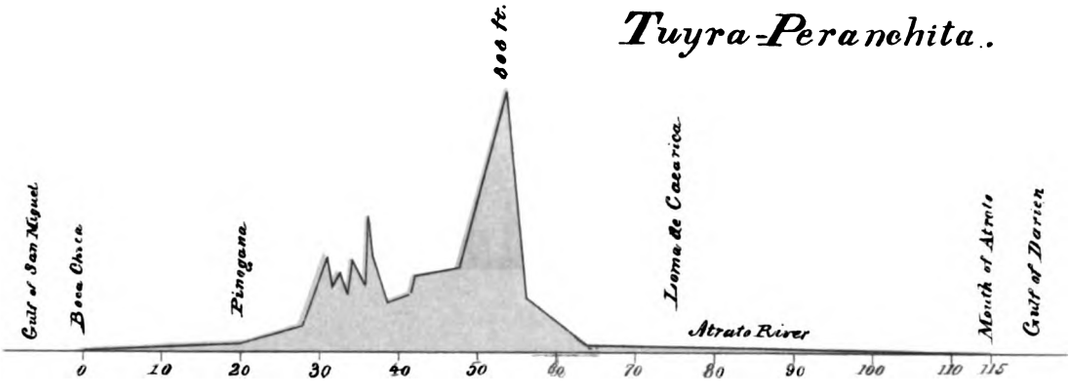
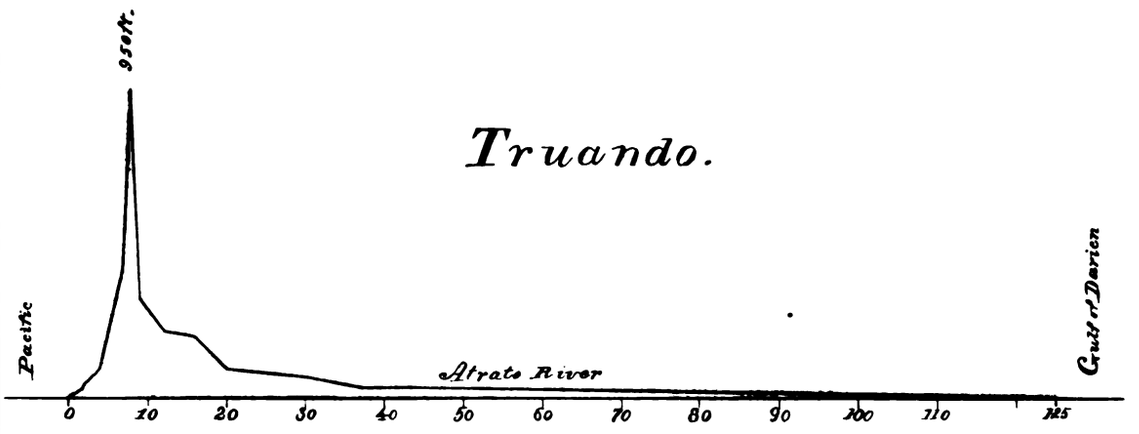
Tuyra-Peranchita.



Truando.



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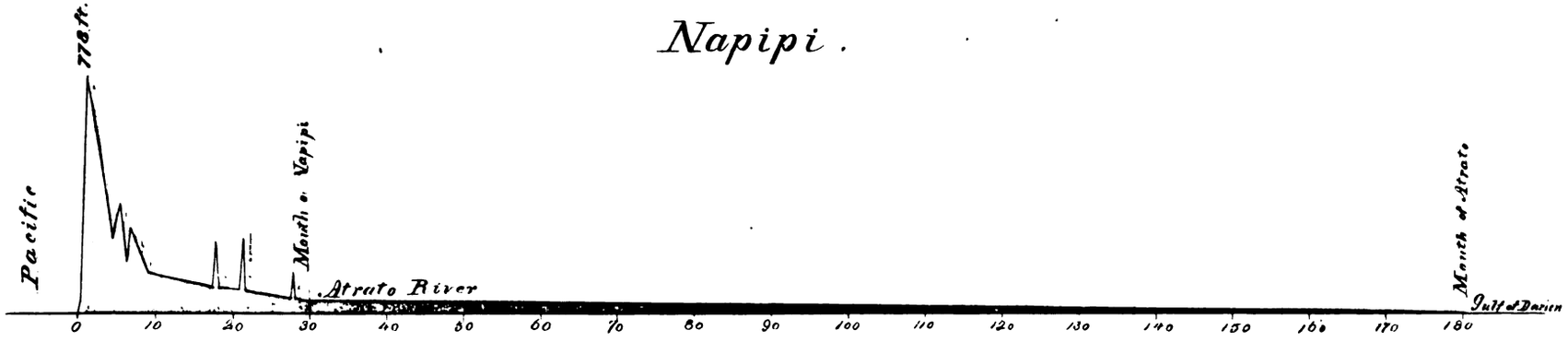
Napipi.



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sible to state exactly the limits of rainfall in each of these sections, as no regular system of meteorological observations from year to year has ever been maintained. The rainfall at Virgin Bay during a period of eight months, which included the rainy season, was 47.79 inches. This was the result of observations taken during the Nicaraguan expedition of 1872–'73. There is a distinct dry season of between five and six months when work in progress would not be delayed or injured, and but little interruption need be apprehended in the rainy season on that portion of the work lying between the lake and the Pacific, as the rains generally fall at night, with occasional showers during the day.

10. The important physical feature of the route is the existence of Lake Nicaragua. It is not only capable of supplying twenty times the volume of water which the commerce of the world would require in the lockage of vessels, but receiving the drainage of 10,000 square miles of country, distributes the flood waters of that area over its superfice of 2,800 square miles, and thus relieves the San Juan Valley from extensive floods. The lake is 110 miles long with an average width of 30 miles. Its depth, from a point 1,200 feet east from the western shore to within about 9 miles of its outlet, the San Juan River, is at all points as much as 30 feet, and in some places as much as 150 feet. Its elevation above the sea at high tide is 103 feet, and at mean tide 107.63 feet. The rise in the lake does not exceed 5 feet. The San Juan River carries off, when the lake is full, from 12,000 to 15,000 cubic feet of water per second. The river falls but 2 feet in 28 miles, and then 12 feet in the following 9 miles. There are two rivers emptying into the lake—Rio Rama and Rio Frio—near its outlet. They are both large streams and their flow is generally parallel to the course of the San Juan, but in the opposite direction to the flow of this river. The result is that the San Juan has a very small watershed and does not receive a stream of any magnitude between the lake and the point where the San Carlos enters it. The maximum rise of the San Juan is between 4½ and 5 feet. Its width in the upper portions is from 1,200 to 1,500 feet; near the dam the greatest width is about 600 feet, but it has here its greatest depth. In view, then, of the conditions which arise from the existence of the lake and the character of its outlet, it can be positively stated that there is no route on the American Isthmus where the natural surface drainage is under such admirable regimen as in Nicaragua. These natural conditions make it an easy matter to provide artificial drainage when necessary, and it has not been found difficult to make provision for every stream crossed by the canal.

11. It can be easily demonstrated that it will be a paying investment, even at twice the estimated cost; and, that without charging more than $2 per ton toll, a yearly interest of at least 8 per cent. can be paid on $100,000,000.

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CHAPTER XIV.

THE IMPORTANCE OF THE PROBLEM OF INTEROCEANIC COMMUNICATION—THE BENEFITS WHICH ARE LIKELY TO ACCRUE TO COMMERCE FROM THE CONSTRUCTION OF AN INTEROCEANIC SHIP-CANAL—ROSS' ESTIMATE, SHOWING INCREASE OF EARNINGS IN ONE YEAR BY A VESSEL USING THE CANAL INSTEAD OF "HORN" ROUTE—COMMERCIAL STATISTICS BEARING UPON THE PROBABLE TONNAGE WHICH WOULD PASS THROUGH THE CANAL IN ONE YEAR—COLLINS' ESTIMATE OF GAIN IN TIME AND DISTANCE IN USING THE CANAL.

An American interoceanic canal will bring the grain markets of Europe within easy distance of the west coast of the Americas, and the manufactured goods of our Eastern States within competitive distance of the Chinese markets.

China does not want the products of our soil; on the other hand, she does want our manufactures. Europe does not need our manufactures, but she does need our breadstuffs.

When the West can land the varied products of its soil in European markets in thirty days, without breaking bulk and at reasonable rates, and the East, under the same conditions, can land the products of its looms and factories in the Orient in forty days, America, and especially the United States, will have made a giant's stride in prosperity.

In 1880, had the freights on wheat alone been 8 cents less per bushel, $3,360,000 would have been saved to the Pacific wheat-growers. This amount and much more is annually taken out of the country, for the carrying trade is mainly in the hands of foreigners.

The guano and niter traffic of Peru and Chili; the ice trade of the United States and Canada; the whale fisheries and the coasting trade of the United States; the coffee, cochineal, cocoa, indigo, sugar, cattle, India rubber, dye and cabinet wood trades of Central and South America, would be incalculably benefited. The fishing fleets of the United States and Canada, now idle during the winter, would find profitable trade in coasting between the Atlantic and Pacific coasts. Considering the existing industries alone, Mr. Frederick M. Kelley estimated that, had the canal been in operation in 1858, the saving to the United States would have amounted to $35,995,930.

The substantial benefits the Americas would derive do not end here. At whatever point on the Isthmus the canal be cut, it must have one terminus in the "Central Sea of America."

"The two great arteries of the continent, the Mississippi and the Amazon, fed by tributaries with navigable length of channel more than enough to encircle the globe, bring from their shores the products of every clime" to the "Heart of the Ocean."

The three great outlets of American commerce, the Hudson, the Mississippi, and the Amazon, are all within ten days' sail of any isthmian canal. Thus the United States will distance England in the race for commercial supremacy. For then, instead of England meeting us in "India, China, and our own Pacific coasts with the advantage of some ten days' sail, the tables will be turned, and we shall have the advantage of some twenty or thirty days, thus making a difference of thirty or forty days under canvas." The Atlantic and Gulf ports of America would then be upon "the wayside of the great commercial thoroughfare to India and China, and all the markets of the Pacific."

This Isthmus "is the barrier which separates us from six hundred million people—three-fourths the population of the earth. Break it down, therefore, and this country is placed midway between Europe and Asia, this sea becomes the center of the world and the focus of the world's commerce. Open this as a highway, and you will give vent to commerce, scope to energy, and range to enterprise, which in a few years hence (1848) will make gay with steam and canvas parts of the ocean which are now unfrequented and almost unknown. Old channels of trade will be broken up, new ones opened. All the elements of human greatness which river, land, and sea can afford are here crowded together. For their full development easy access to the Pacific is necessary."

The Atlantic and Pacific must join hands across the Isthmus, for "the best means to promote

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Map of the World, showing the central position of the American Isthmus, with reference to the great water surface of the globe, and also the present routes for sailing vessels and those that would be available if a canal existed.

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Map of the World, showing the central position of the American Isthmus, with reference to the great water surface of the globe, and also the present routes for sailing vessels and those that would be available if a canal existed.

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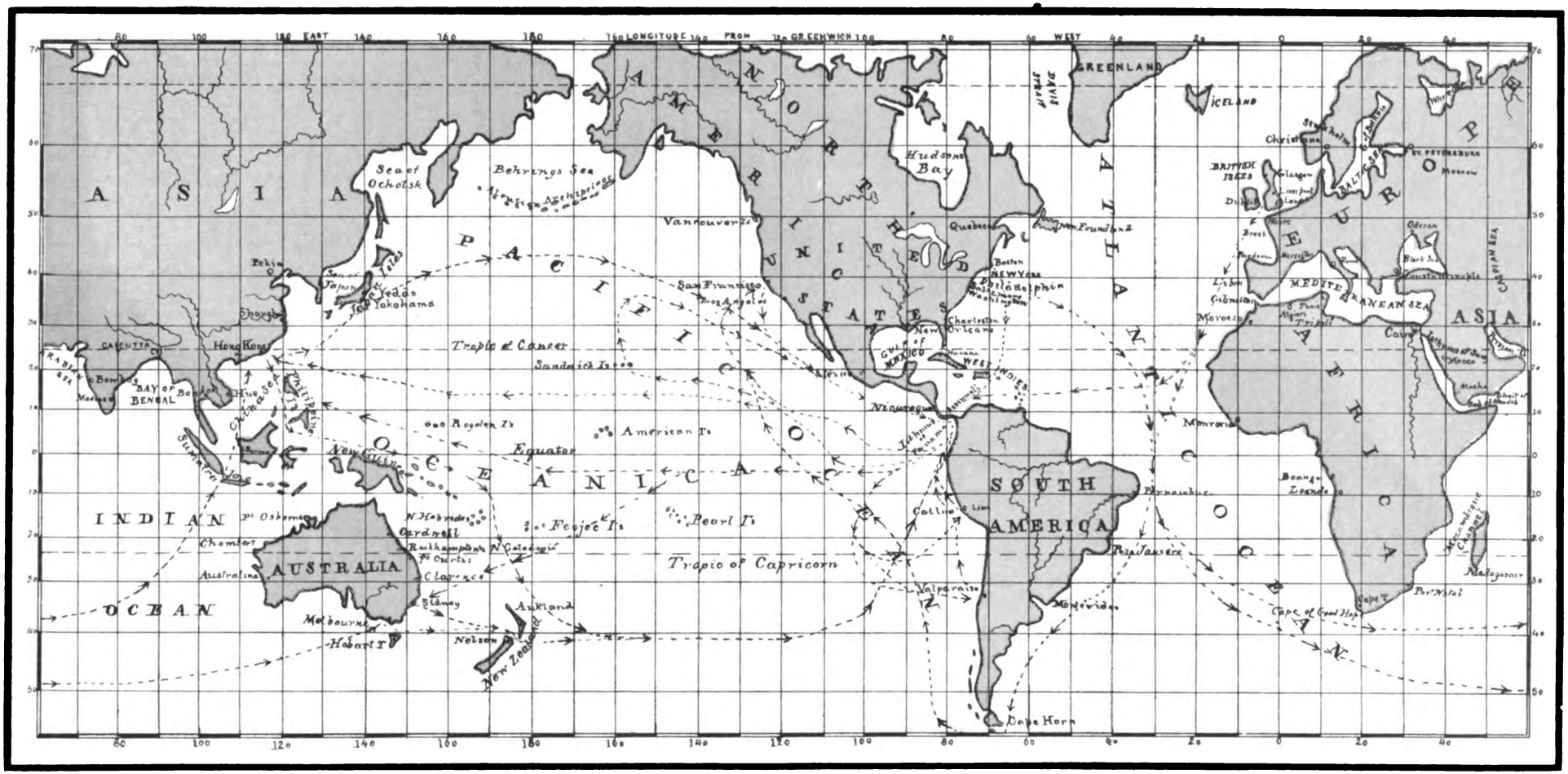

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the interests of humanity is to knock down the barriers which separate men and nations and races." "War and commerce have civilized the world. The time for war has gone by; commerce alone pushes its conquests." "Progress and improvement are the order of the day. Instead of throwing obstacles in the way of commerce, the spirit of the age demands for it every facility that is calculated to promote friendly contact and free intercourse among nations."

The time has arrived, as M. F. Maury predicted thirty-four years ago, when he said, "Men will come from the four quarters to urge with purse and tongue the construction of a ship-canal."

It may not be amiss to quote here some extracts from a remarkable pamphlet written in 1846, by Louis Napoleon, afterwards Emperor of the French.

"The geographical position of Constantinople is such as rendered her the queen of the ancient world. Occupying, as she does, the central point between Europe, Asia, and Africa, she could become the *entrepôt* of the commerce of all these countries, and obtain over them an immense preponderance; for in politics, as in strategy, a central position always commands the circumference. This is what the proud city of Constantine could be, and this is what she is not, because, as Montesquieu says, 'God permitted that Turks should exist on earth, a people most fit to possess uselessly a great empire.' There exists in the New World a state as admirably situated as Constantinople, and we must say up to this time as uselessly occupied. We allude to the State of Nicaragua. As Constantinople is the center of the ancient world, so is the town of Leon, or rather of Massaqua, the center of the new, and if the tongue of land which separates its two lakes from the Pacific ocean were cut through, she would command by virtue of her central position the entire coast of North and South America. The State of Nicaragua can become better than Constantinople the necessary route of the great commerce of the world, and is destined to attain an extraordinary degree of prosperity and grandeur.

"France, England, and Holland have a great commercial interest in the establishment of a communication between the two oceans, but England has, more than the other powers, a political interest in the execution of this project. England will see with pleasure Central America becoming a powerful and flourishing state, which will establish a balance of power by creating in Spanish America a new center of active enterprise, powerful enough to give rise to a great feeling of *nationality* and to prevent, by backing Mexico, *any further encroachments from the north.*"

Moreover, the American interoceanic canal antagonizes neither Suez nor the great transcontinental railways.

"The great lines of commercial intercourse and civilization are distinct, and therefore invite no prejudicial rivalry between the two—the eastern and the western isthmus ship canals. The Suez Canal is the opened gate for the inland sea route of Europe and North Africa with Southern Asia and its archipelago. The canal through the American isthmus would invite the commerce of Europe with our own commerce to the whole of the western coast of the Americas, to Northern China and Japan, and southwardly to the Australian continent."

As the canal would benefit the Pacific coast more than any part of our Union, a most rapid and material increase, both in population and riches, is to be expected there. It is to the manifest interest of railways to favor the most economic means of transporting those bulky products of the soil which they cannot transport without a commercial loss. For by thus promoting the increase of these industries, they gain their recompense in the increased travel and the light valuable freights which the increased necessities of a larger and a richer population require. In considering this question it would be well to bear in mind that the cereals of the West cannot be brought competitively into European markets by rail, and it may not be amiss to point to the fact that the wonderful growth in wealth and population of the Mississippi Valley is the result of that continued cheapening of transportation arising from improvements by land and competition by water.

To demonstrate the practical benefits to be derived by owners of vessels using a canal through the American Isthmus, the following letter is presented:

"NEW YORK, *March* 16, 1880.

"DEAR SIR: Referring again to your letter of the 13th ultimo, I note the question you raise in relation to a canal across the Isthmus, viz, 'the difference in time of transit and the excessive dangers via Cape Horn.'

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"Both these assertions must be conceded, though some ship-owners state that the captains are now so familiar with the "Horn" voyage that actual losses are less than in former years.

"The actual voyage of a vessel, with the practical figures, compared with a possible voyage via the Isthmus, should give us an approximation to the actual result. I will venture to present a few figures, leaving to others the detection of errors.

"Suppose a sailing-vessel commences to load in New York January 1 for the voyage around Cape Horn to San Francisco, vessel worth $60,000. She sails February 1, and arrives in San Francisco June 1. She is six weeks discharging and loading cargo of California wheat for Liverpool, leaving San Francisco July 15, arriving in Liverpool November 15, where she discharges and proceeds in ballast to New York, arriving there about December 31, a year's business completed.

"We will estimate that the owners of the ship realize $8.50 net per ton on the voyage from New York to San Francisco, and this amount will be collected when the cargo is delivered in San Francisco, the average date of collection in this instance being:

June 15. Ship 2,000 tons, at $8.50 net	$17,000 00
Interest on above at 5 per cent. per annum from June 15 to December 31.	460 39
July 15. Leaving San Francisco for Liverpool with 2,000 tons of California wheat, at $13 net per ton	26,000 00
And this freight money is collected—	
December 1. Interest at 5 per cent. per annum to December 31	108 33
December 31. Arrives in New York	43,568 72
Deduct one year's insurance upon ship, valued at $60,000, at 6 per cent. net	3,600 00
Received by owners, one year's business, Cape Horn route	39,968 72

"Let us estimate for one year's business by the 'canal' route. Had the Isthmus canal been open on the above 1st day of January, then the same ship advertising for San Francisco by that route would realize more freight money for her owners; thus, leaving New York February 1, as before, and arriving in San Francisco April 1, making the trip in sixty days, freight will be collected upon the delivery of the cargo, about—

April 15. Ship 2,000 tons, at $12.50 net per ton, or $25,000, less $6,000 paid as toll to the canal	$19,000 00
April 15. Interest on above at 5 per cent. per annum to December 31	672 86
May 15. Leaving San Francisco for Liverpool with 2,000 tons California wheat, at $15 per ton net, or $30,000, less $6,000 paid as toll to the canal	24,000 00
Arriving in Liverpool July 15, where the freight money is collected, about—	
April 1. Interest on above at 5 per cent. per annum to December 31	500 00
Leaving Liverpool, ship proceeds to New York in ballast, where she again takes in cargo for San Francisco, sailing October 15 with 2,000 tons of cargo, at $12.50 net per ton, or $25,000, less $6,000 paid as toll to the canal	19,000 00
Arriving in San Francisco, where freight money is collected, December 31.	63,172 86
Although the vessel sails through the canal, the risk of one more voyage must be taken into account, and the charge for insurance on the ship will be the same as for the 'Horn' voyage, $60,000, at 6 per cent. net, $3,600, and as the ship enters one more port during the year we add, for expenses, $3,000, making together	6,600 00
Received by owners of ship, 'canal' route, one year	56,572 86
Received by owners of ship, 'Horn' route, one year	39,968 72
Gain by using canal route, vessel 2,000 tons	16,604 14

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"This is over 27.5 per cent. in favor of the Isthmus Canal.

"It may at first appear that we should charge the wages of both officers and men, but it would not alter the result, since the vessel is at sea two hundred and ten days during the year when sailing through the canal, and two hundred and seventy days in the 'Horn' voyage; but should we make the charge it would simply increase the gain of the canal route.

"The greater wear and tear of the voyage via Cape Horn has not been taken into account, and certainly that, with the excessive toll of $3 per ton charged, and the $3,000 port expenses, will more than compensate for any advantages which can be claimed for the 'Horn' route.

"Should an objector claim that one hundred and twenty days for one route and sixty days for the other may not be in all cases correct, we would point out that if the number of days is increased or decreased in one estimate it may be correspondingly changed in the other.

"Although a vessel from New York to San Francisco on the 'Horn' voyage may sail over a line less than 14,000 miles long, she probably will traverse a line between 17,000 and 18,000 miles long. In the same way a vessel passing through the canal may sail to San Francisco along a line of 6,000 miles, but she would probably cover 9,000 miles in the trip.

"It will be observed that 150 miles a day for sixty days gives 9,000 miles for the 'canal,' and 150 miles per day for one hundred and twenty days gives 18,000 miles for the 'Horn.'

"A few days more or less in either estimate cannot materially alter the 27.5 per cent. of result. But even if the voyages are longer, and receipts do not all fall within the limits of one year, let us throw off 7.5 of our 27.5 per cent., and we still have 20 per cent. remaining on $60,000, or a gain for the ship-owner of $12,000 by using the canal route instead of that via Cape Horn. But had our estimates shown that neither route could claim a preference on account of any considerable gain or difference, still the ship-owner would quickly select the route which would, in the least time, bring his vessel to her destination with the least danger of strain or injury.

"It seems to me from a cursory examination of the map that a portion of the sailing tonnage of Europe, trading with China, Japan, Philippine Islands, Borneo, New Guinea, Australia, and possibly Java and Sumatra, would pass through our Isthmus Canal; but to arrive at any satisfactory result the actual sailing lines of vessels around the Cape of Good Hope, together with the ocean and air currents, with the dangers of the various seas, are all to be carefully considered and balanced.

"That a canal through the American Isthmus will greatly benefit our people, particularly on the Pacific coast, and revive our merchant marine, I steadfastly believe; and if it were possible that iron in the future could remain high in price, our people would commence the building of large wooden vessels, fitted with screw machinery to propel them at a low rate of speed, for freight purposes only.

* * * * * * * *

"Very truly yours,

"ARTHUR B. ROSS.

"Prof. J. E. NOURSE,
"*Naval Observatory, Washington.*"

The rate of toll used in the above estimate ($3 per ton) is that which M. Lesseps advertises in a circular addressed to the public in the winter of 1880. This rate does not appear excessive when applied to the tonnage capacity of a vessel, as shown by the above estimate, but when applied as M. Lesseps is authorized to use it by the concession which he holds, it becomes an instrument of extortion. In regard to this point the Lesseps circular is clearly misleading, as is shown by the application of the rate which Mr. Ross makes to the tonnage capacity of a vessel. With nothing to indicate an unusual method of arriving at the gross amount of toll, Mr. Ross applies the rate to the number of tons of freight which the vessel carries; but M. Lesseps gets his tons, not from the freight but from a different source, and by this means increases the range of toll to nearly three times the indicated rate. This is done by computing the number of tons contained in the parallelopiped determined by the lines of greatest length, greatest breadth, and greatest depth of the immersed hull of the vessel, a cubic meter being regarded equal to a ton. Port charges, pilotage, wharfage, light-house dues, &c., are all determined by the same measurements.

The handsome increase of revenue shown by the above estimate would, therefore, be decreased

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by M. Lesseps to an amount that would just make it pay the merchant to use the canal. The ship estimated upon pays $18,000 for the three trips which she makes. M. Lesseps' toll for a corresponding number of trips could range as high as $54,000.

In the report of the executive committee to the members of the Provisional Society of the "Nicaragua Ship Canal Company," the application of the rate of toll is to the tonnage capacity of the vessel. Introducing the rates of toll therein considered ample to secure a paying investment to capital, in the estimates of Mr. Ross, there is a still better showing for a year's work. Mr. Ross's estimate at $3 per ton gives a gain of 27.5 per cent. on the $60,000 invested=$16,604.14. In the report referred to it is assumed that a charge of $2.50 per ton, including canal tolls and all other charges, would be the maximum rate for a minimum of business, while with a business not beyond that estimated for the Panama scheme the maximum charge of $1.50 per ton would pay the investors 10 per cent.

Using these rates in the estimate, it will be seen that at a charge of $2.50 per ton there would be a gain of 32.5 per cent., or $19,604.14; while with the lower rate of $1.50, the gain would be 42.5 per cent., or $25,604.14. An average of the above rates would be $2.33, which would amount to a gain of 34.3 per cent., or $20,604.14. By still further reducing the percentage by 9.3 (Mr. Ross rejects 7.5) there remains a gain of 25 per cent., or the sum of $18,687.97. This illustrates, in a practical way, that the canal would prove remunerative not only to those who control it but to those who use it as well.

Various estimates of the amount of tonnage that would use the canal have been made:

	Estimated tons.
Dr. Long, American consul at Panama	3,000,000
Admiral Ammen	3,762,000
San Francisco Board of Trade	5,000,000
S. L. Phelps, on data furnished by Bureau of Statistics	2,938,386
Report of executive committee to Provisional Society of Nicaragua Ship Canal Company	3,706,426
T. C. Clarke	3,000,000
Admiral C. H. Davis, U. S. N	4,000,000
MM. de Lesseps and Levasseur	6,000,000
Report of Secretary of Treasury to the House of Representatives, in 1872, places the tonnage at	2,834,786
	34,241,598
Mean	3,804,622

The tonnage of the world in 1870 amounted to 17,963,293 tons, and in 1879, to 20,395,815 tons. These amounts were made up by steam and sail tonnage as follows:

Years.	Steam.	Sail.
	Tons.	*Tons.*
1870	2,466,498	15,496,795
1879	4,366,221	16,029,594
Gain in nine years	1,899,723	532,799

From this it will be seen that while the sailing tonnage has actually increased, it has not done so at a rate to compare with the increase of the steam tonnage, which has been facilitated by many causes, prominent among which was the opening of the Suez Canal. Sailing vessels cannot use this canal to advantage; hence the increased commerce resulting from its construction has called into existence much of the increased steam-tonnage. It is very probable that in the event of the opening of a canal by way of Nicaragua the sailing tonnage would increase at a remarkably rapid rate, as this route lies in a region which is highly favorable to sailing vessels.

The two following tables will show the enormous gain in time and distance by using a route as unfavorably situated as the Atrato–Napipi. For the relative gain in time and distance by way of Panama and Nicaragua, see Lieutenant Collins's estimate in Appendix A.

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Many quotations and facts in this chapter have been taken from a remarkable letter by Lieut. M. F. Maury to the Hon. J. A. Rockwell, M. C., on the subject of the Panama Railway and interoceanic communication by ship-canal. The letter is given in full in Appendix B.

Table showing the probable gain in distance and time to be effected for sailing ships to and from the port of New York by a ship-canal across the Isthmus of Darien, over the route surveyed by Commander T. O. Selfridge, U. S. N.

[Prepared by Lieut. FREDERICK COLLINS, U. S. N.]

From—	To—	By present route.			Via canal.		Gain.	
		Route.	Distance.	Days.	Distance.	Days.	Distance.	Days.
			Miles.		*Miles.*		*Miles.*	
New York	Hong-Kong	Via Cape of Good Hope	14,930	110	12,480	83	2,450	27
Do	Shanghai	do	15,200	115	12,200	81	3,000	34
Do	Yokohama	do	15,750	119	11,550	79	4,200	40
Do	Manila	do	13,700	108	12,260	80	1,440	28
Do	Batavia	do	12,170	105	13,425	87		18
Do	Sydney	do	13,220	105	10,480	75	2,740	30
Do	Valparaiso	Via Cape Horn	9,760	90	6,510	52	3,250	38
Do	Callao	do	11,100	105	6,710	53	4,390	52
Do	Honolulu	do	14,500	121	7,400	54	7,100	67
Do	San Francisco	do	14,840	130	7,470	58	7,370	72
Hong-Kong	New York	Via Cape of Good Hope	14,060	110	11,875	87	2,785	23
Shanghai	do	do	16,000	113	11,305	80	4,695	33
Yokohama	do	do	16,070	114	10,370	77	5,700	37
Manila	do	do	14,010	109	12,035	88	1,975	21
Sydney	do	Via Cape Horn	13,410	110	10,390	70	3,020	40
Valparaiso	do	do	9,780	90	4,965	42	4,815	48
Callao	do	do	11,120	100	3,690	32	7,430	68
Honolulu	do	do	15,760	110	8,055	63	7,705	47
San Francisco	do	do	14,970	125	5,980	50	8,990	75

NOTE.—The distance by present route are in nautical miles, measured on the routes now generally pursued; the times are actual averages obtained from various reliable sources.

Table showing times and distances by steamer routes.

[Prepared by Lieut. FREDERICK COLLINS, U. S. N.]

From—	To—	Distance.	Days.
Cupica	Sydney	7,670	30.0
Do	Hong-Kong	9,865	37.0
Do	Manila	9,705	37.0
Do	Shanghai	9,305	36.0
Do	Yokohama	8,375	33.0
Do	Honolulu	4,855	18.5
Do	Batavia	10,700	41.0
Sydney	Cupica	7,670	32.0
Hong-Kong	do	9,820	38.0
Do	do	9,435	36.5
Manila	do	10,410	41.0
Do	do	10,025	38.0
Yokohama	do	8,310	33.0
Do	do	7,825	30.0
Honolulu	do	5,000	19.0
Batavia	do	10,820	44.0

NOTE.—For times and distances *from* New York add 2,200 miles and 11 days: for times and distances *to* New York add 2,200 miles and 11 days.

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APPENDICES.

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APPENDIX A.

REPORT OF THE UNITED STATES INTEROCEANIC CANAL COMMISSION.

WASHINGTON CITY, *February* 7, 1876.

To the President of the United States:

The commission appointed by you to consider the subject of communication by canal between the waters of the Atlantic and Pacific Oceans across, over, or near the isthmus connecting North and South America, have the honor, after a long, careful, and minute study of the several surveys of the various routes across the continent, unanimously to report:

1. That the route known as the "Nicaragua route," beginning on the Atlantic side, at or near Greytown; running by canal to the San Juan River; thence following its left bank to the mouth of the San Carlos River, at which point navigation of the San Juan River begins, and by the aid of three short canals of an aggregate length of 3.5 miles reaches Lake Nicaragua; from thence across the lake and through the valleys of the Rio del Medio and the Rio Grande to what is known as the port of Brito, on the Pacific coast, possesses, both for the construction and maintenance of a canal, greater advantages and offers fewer difficulties from engineering, commercial, and economic points of view than any one of the other routes shown to be practicable by surveys sufficiently in detail to enable a judgment to be formed of their relative merits, as will be briefly presented in the appended memorandum.

The data for the conclusions of the commission will be found in the reports of the various surveys and examinations made under the direction and auspices of the Navy Department, copies of which are transmitted herewith.

A statement relating to these surveys and examinations, with a brief account of the characteristic features of the routes, will be found in the accompanying memorandum prepared by the commission.

We have the honor to be, with high respect, your obedient servants,

ANDREW A. HUMPHREYS,
Brigadier-General, Chief of Engineers, U. S. A., &c.
C. P. PATTERSON,
Superintendent United States Coast Survey.
DAN'L AMMEN,
Commodore, and Chief of the Bureau of Navigation.

ACCOMPANYING MEMORANDUM.

At the time of the appointment of the commission various surveys for an interoceanic ship-canal across this continent had been made by different parties, and others were in progress under the Navy Department. No formal meeting occurred until the surveys in progress were completed and their results presented in the shape of reports, maps, and plans, upon the routes which, as presented, appeared the most practicable.

On the fifth day of February, 1874, a sitting was held; general information bearing upon the subject was discussed, as well as that derived from the recent surveys made under the Navy Department, as far as then executed.

Captain Shufeldt and Commanders T. O. Selfridge and E. P. Lull, of the Navy, were invited and appeared before the commission for the purpose of making verbal explanations relating to the different surveys of which they had charge. Capt. R. W. Shufeldt had charge of those of the Isthmus of Tehuantepec; Commander T. O. Selfridge of those including the San Blas and Chepo route, and all lying south and east of that line; and Commander E. P. Lull of those via the Nicaragua Lake, and afterward of those on the Isthmus of Panama, as will be mentioned hereafter.

It was agreed to take up the discussion of the routes from the north toward the south, and to request the assignment of Army engineers for the purpose of passing over and making a personal examination of the relative practicability of two of the proposed routes, and also to examine and report upon whatever related practically to the execution of the works.

The commission, therefore, asked the aid of the honorable Secretary of the Navy, who kindly supplied the necessary facilities for the desired examination through our naval vessels; the proper officers who had been engaged on those surveys were also detailed to facilitate the examination, and several civil engineers were invited to accompany the parties and to report their views after personal inspection.

By request of the commission, Maj. Walter McFarland and Capt. W. H. Heuer, United States Engineers, and Prof. Henry Mitchell, of the United States Coast Survey, made the personal examination desired, accompanied by

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General Jacob Ammen and Civil Engineer D. S. Walton, whose observations and services were not the less valued or appreciated because they were honorary.

The reports made by the gentlemen are herewith appended.

A discussion of the Nicaragua and Atrato-Napipi routes, after the receipt of the preliminary reports of these gentlemen, induced the commission to ask a close instrumental survey on the Isthmus of Panama. This was rendered further desirable by surveys that were said to have been made, the reports of which had been asked for of those concerned and best informed without obtaining definite information. The commission has to express its obligations for the prompt and efficient manner in which the honorable Secretary of the Navy caused this survey to be made by Commander E. P. Lull, U. S. N., a corps of junior officers, and Civil Engineer A. G. Menocal, U. S. N., and also for the actual line of location of the Atrato-Napipi route, and other information, by Lieut. F. Collins, U. S. N., and party, who had previously been under the command of Commander T. O. Selfridge. In this manner the collection of information was completed as deemed necessary for a decision upon the subject. The commission is pleased to recognize the laborious works, conducted through a series of years, by naval officers, under the instructions of the Navy Department, on a field of operations extending over large tracts of territory, and believed to preclude the existence of as favorable lines for the construction of an interoceanic ship-canal as those herein particularly presented for consideration.

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APPENDIX B.

A COMPARISON OF THE PANAMA AND NICARAGUA ROUTES, SHOWING THE GAIN IN TIME BY A SAILING VESSEL USING THE LATTER.

By Lieut. FREDERICK COLLINS, U. S. N.

STATEMENT OF LIEUT. FREDERICK COLLINS, U. S. N., BEFORE THE SELECT COMMITTEE OF THE HOUSE OF REPRESENTATIVES ON THE INTEROCEANIC CANAL.

WASHINGTON, D. C., *February* 28, 1880.

[Lieut. Frederick Collins, U. S. N., read the following on a comparison of the effects of the winds and currents of the Pacific Ocean upon the routes of sailing vessels to and from the western termini of the proposed interoceanic ship-canals at Nicaragua and Panama:]

The unfavorable character of the prevailing winds and currents of the Pacific Ocean in the vicinity of the west coast of Intertropical America for navigation by sailing vessels has long been known, and, in connection with the interoceanic canal projects, it is frequently commented upon as a disadvantage of the Panama route.

The subject seems to be very imperfectly understood by the public at large, and many misconceptions and exaggerated notions are prevalent concerning it. No less person than Lieutenant Maury, "the father of the physical geography of the sea," is said to have proclaimed that even if the Isthmus of Panama were to be divided by a convulsion of nature, it could never become a highway for sailing vessels on account of these unfavorable winds, calms, and currents.

I could hardly venture to question the opinion of so eminent an authority as Lieutenant Maury on this subject, but I think it safe to say that, if we wish to consider the question candidly and fairly, we will find that this dictum, like most other sweeping assertions, can be accepted only with reservations and qualifications.

It is certainly true that the prevailing meteorological conditions and oceanic currents in the vicinity of the west coast of the Isthmus of Panama are exceedingly unfavorable for either the approach or departure of sailing vessels. Still, it required something of a stretch of the imagination to believe that they can be so unfavorable to induce vessels to brave the stormy passage around Cape Horn in preference to going by way of the Isthmus, should nature or man provide a gateway.

In 1872, I had occasion, under directions from the Bureau of Navigation, to make a close examination of this subject, the results of which were published in Commander Selfridge's report of his surveys on the Isthmus. As a result of these investigations, I was led to conclude that, comparatively speaking, no great difficulty need be experienced in getting from the vicinity of the Bay of Panama to a place where good winds might be found. A considerable detour from the most direct route would be necessary in most cases, it is true, but a careful computation gave only ten days as the average time that would be consumed in getting a sufficient offing to secure good winds, provided the correct route was pursued.

Now, ten days can hardly be considered a sufficiently formidable loss of time to preclude the use of the Isthmus route by sailing vessels, were it open. Indeed, in comparison of the time that would be saved on most voyages, ten days are a bagatelle. But if ten days can be saved by one isthmus route that must be lost by another, then it becomes a matter of vital interest. And if in the comparison of two routes it can be demonstrated that one of them will bring our east and west coasts nearer by ten days than another, it appears to me that this fact alone would be sufficient to decide us in our choice.

I propose now to demonstrate, beyond the possibility of denial, by a consideration of the winds and currents of the Pacific Ocean, that the Nicaraguan route will give even a greater gain than that as compared with Panama or any route south of Panama on a voyage from New York or New Orleans to San Francisco. [A diagram showing the wind and calm regions of the Pacific in the vicinity of the west coast of Central America and the United States, as well as the routes from Panama and Nicaragua to San Francisco, was here exhibited to the committee and explained by Lieutenant Collins.]

After this explanation we can understand why it was that Lieutenant Maury, writing in 1854 of the passage from Panama to San Francisco under sail, said that, as then made, it was "one of the most tedious, uncertain, and vexatious known to navigators;" and that the voyage from Valparaiso to California was shorter in point of time than that from Panama, although the latter, as regards distance, was not half so long as the former. At that time the practice was either to keep up along close to the coast or stand out west from Panama until the northeast trades were reached. Both were wrong and resulted in long passages. In 1854 an officer of the Navy, writing to Lieutenant Maury, said (see page 773, Maury's Sailing Directions, eighth edition): "I learned on my arrival at Panama that great numbers of sailing ships were in the habit of resorting thither for the purpose of taking freight and passengers to San Francisco,

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but, to my surprise, I learned they seldom made the passage under ninety days, and often were one hundred and twenty days on the way. * * * One of the clipper ships some time since made the passage in forty-five days by standing to the southward as if bound for Callao, and making all her westing in the southeast trades south of the line."

Acting on this hint, Maury began an investigation of the subject, and on page 775 of his Sailing Directions he sums up his conclusions in the following suggestions for the consideration of navigators bound northwest from Panama:

"From the Bay of Panama make the best of your way south till you get between 5° north and the equator. Being between these parallels it will be for the navigator to decide whether he will shape his course west and keep between them until he crosses the meridian of 95° west, or whether he will cross the equator and make his westing in south latitude with the southeast trades on his quarter. The winds he finds between 5° north and the line must decide this question for him. If he can get west here with a good breeze he should crack on, and when his good wind fails him steer south again. * * * Therefore, in coming out of the Bay of Panama, and after crossing 5° north in any season, make a southwest course if the wind will allow. If the wind be southwest, brace up on the starboard tack; if it be south-southwest, stand west if it be a good working breeze. But if it be light and baffling, with rain, know that you are in the *Doldrums*, and the quickest way to get clear of them is by making all you can on a due south course."

This route, suggested by Maury (which corresponds essentially with the one projected on this diagram), was at once followed by navigators, and with such good results as to reduce the average length of passage to San Francisco from ninety days to thirty-seven days. My computations gave a result of thirty-six days as the average time from Cupica, which would be about equal to thirty-eight from Panama; a result in close agreement with the average time as above stated, according to Berghaus and other authorities. The foregoing has been necessary to demonstrate the correctness of the route from Panama to San Francisco, which I have projected on this diagram, and which certainly looks to be a very roundabout way. It is a case, however, as I have shown, in which "the longest way round is the shortest way home."

I will now briefly demonstrate the correctness of the route which I have projected from Nicaragua to San Francisco, for if these routes are not correct, of course the whole business of comparison falls to the ground. This route, as you see, lies straight out to the westward from the coast through the monsoon belt, the edge of which is reached at about the one hundred and tenth meridian. It then turns a little to the northward through the upper part of the Doldrum region so as to strike the northeast trades at the nearest point. Thence it lies to the northward and westward through the trade winds; finally turning to the eastward and reaching San Francisco through the belt of westerly winds that lies above the "trades." This route I consider to represent as nearly as possible the average distance that sailing ships will traverse in making this passage, taking the year round. At times ships getting a "good slant" of southerly winds in the monsoon belt will make the trip much shorter. At others, they will be forced away to the southward by the "northers" and make it much longer. In general, during the winter months, when northerly winds prevail along the coast, the route will be longer. On the other hand, during the summer when the southerly winds prevail, it will be shorter. On the average, the route laid down will give a very close approximation to the distance sailed. Its length is 3,240 miles, and allowing that the rate of sailing will on the average be about the same as on the route from Panama, the time to make the trip will be twenty-three days. Comparing, now, the distance and times on the two routes we get the following:

	Miles.	Days.
Panama to San Francisco	5,350	37
Nicaragua to San Francisco	3,240	23
Difference in favor of Nicaragua	2,110	14

On the return from San Francisco the difference in favor of Nicaragua is less marked, but still worthy of notice. The average distance to be sailed will vary somewhat with the season, being considerably longer in the summer than in the winter. Following is the comparison for the return during both seasons:

OCTOBER TO APRIL.

	Miles.	Days.
San Francisco to Panama	3,600	26
San Francisco to Nicaragua	3,000	22
Difference in favor of Nicaragua	600	4

APRIL TO OCTOBER.

San Francisco to Panama	4,000	31
San Francisco to Nicaragua	3,400	26
Difference in favor of Nicaragua	600	5

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The foregoing figures speak for themselves. They show that a canal at Nicaragua will bring New York or New Orleans nearer to San Francisco by nineteen days than will a canal at Panama or any of the proposed routes south of Panama. What other argument can be necessary to show the direction in which American interest lies?

A comparison of routes to other ports of the Pacific, while perhaps of less importance, is so interesting that I will ask your patience while I state briefly the results without going into details.

To China, Manila, or Japan the difference in favor of the route from Nicaragua over that from Panama is 800 miles and five to six days.

To the Sandwich Islands the difference in favor of Nicaragua is 1,100 miles and seven to eight days.

To India, Batavia, Australia, and New Zealand the difference in favor of Nicaragua is 400 miles and two to three days.

Returning from China, Manila, Japan, or the Sandwich Islands the difference in favor of Nicaragua is 600 miles and four to five days.

Coming, now, to a comparison of routes to ports on the west coast of South America, we might naturally suppose that here the Nicaraguan route would be at a marked disadvantage as compared with Panama; but, curiously, enough, such is not the case. A comparison shows that even to Valparaiso, or Callao, there is a difference of 200 miles and one to two days in favor of the route from Nicaragua over that from Panama. On the return from these places we find the sole instance in which the route to or from Nicaragua appears at a disadvantage, the difference being about 500 miles and four days; this time in favor of Panama.

All the foregoing distances are given in nautical miles which contain about 6,080 feet each, while the ordinary or statute mile contains but 5,280.

The foregoing results have reference to sailing ships, and the saving for steamers will not be nearly as large; amounting, in fact, only to the direct distance between the two Pacific termini. This is about 650 miles, and as it would be gained both ways, it would amount in the round trip to San Francisco to a saving of 1,300 miles, which in a ten-knot steamer would be a matter of five days.

Now, M. de Lesseps and the supporters of his Panama project tell us that the carrying trade of the world has passed into the hands of steamers, and that the sailing vessel is obsolescent and may be counted out of the problem. I desire, therefore, to call your attention to a few brief statements which will prove that the sailing vessel as yet holds her own against the steamer much better than is generally supposed. With reference to the commercial marine of Great Britain, I quote from the "Proceedings of the Institution of Civil Engineers," vol. ii, p. 91: "Notwithstanding the immense impetus given to steam shipping by the opening of the Suez Canal, only 41 per cent. of the entire trade with India was carried in 1876 by steam vessels." On page 92 of the same volume is the statement that in 1876 there arrived at the port of New York 1,231 British sailing ships, aggregating 561,503 tons; and 590 British steamers, aggregating 1,588,113 tons. On page 94 it is stated that in 1876 the total registered number and tonnage of all sailing and steam vessels, belonging to the British Empire, were 32,317 sailing vessels, aggregating 5,814,276 tons; and 5,363 steamers, aggregating 2,150,302 tons. This shows the sailing vessels to exceed the steamers by 26,954 in number and 3,663,974 tons in capacity.

Coming, now, to the United States, we find that in 1877 our commercial marine was composed of sailing and steam vessels in the following numbers:

	Number.	Tonnage.
Sailing vessels	17,000	2,322,000
Steamers	4,270	1,126,000
Diff	12,730	1,196,000

Surely these figures do not indicate that the carrying trade of the world has as yet passed into the hands of steamers.

I had prepared the foregoing as the results of my own careful examination of this important subject, when a document came into my hands which corroborates so fully the correctness of my conclusions that I cannot forbear a few quotations. This document is a paper read by Captain Pim, Royal Navy, before the British Association at Sheffield in 1879. In this he quotes from a letter written in 1866 by M. F. Maury, already referred to as a great authority on this subject. From this letter I make the following citations:

"The great importance of one or more *good* commercial highways across Central America being admitted, the whole question of route resolves itself pretty much into a question of cost of construction and facility of ingress and egress by sea to and from the opposite termini; the latter is an affair of winds and currents, and their influence is powerful. Panama has the advantage of *land* transit; Nicaragua has the advantage in winds, terminal ports, and climate. The first is obvious, but to place the latter in a clear light some little explanation is necessary. * * * I have spoken of the calm belt about the equator. Panama is within its range. * * * It is difficult to convey to any one who has never experienced these calms an idea of the obstinacy with which they vex navigation. We are all familiar with calms at sea which last for a few hours, or even a day, but here they last for days and weeks at a time. I have known vessels going to or from Panama to be detained by them for months at a time. * * * On one occasion the British Admiralty, wishing to send one of their vessels into the Arctic Ocean from Panama in time to save the season, had her towed by a steamer through this calm belt and carried 700 miles out to sea before she could find a breeze,

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"These remarks apply to the approach and departure by sea to or from the Pacific terminus of any route across the Isthmus of Panama or Darien, and even with greater force to the Atrato and others on the South American side of Panama. In short, the result of my investigations into the winds and currents of the sea, and their influence upon the routes of commerce, authorize the opinion which I have expressed before and which I repeat, namely: if nature, by one of her convulsions, should rend the continent of America in twain and make a channel across the Isthmus of Panama or Darien as deep, as wide, and as free as the Straits of Dover, it would never become a commercial thoroughfare for sailing vessels, saving the outward bound and those that could reach it with leading winds. * * *

"We come now to the Nicaragua routes. * * * It is to this part of the Isthmus that we must look for a route that shall best fulfill the present requirements of commerce. * * * Vessels under canvas would in the main do the fetching and carrying for the Nicaragua route, which, for reasons already stated, they cannot do for Panama. The aggregate amount of this trade is immense, and it is neither accommodated for Panama nor Panama for it. * * * You will observe at a glance that the Isthmus of Panama or Darien is, on account of these winds and calms, in a purely commercial point of view, the most out-of-the-way place of any part of the Pacific coast of intertropical America."

The foregoing quotations from this eminent authority certainly substantiate fully the deductions that I have already drawn from my own investigations. Better than that, they prove that, my prejudice in favor of Nicaragua, if I have any, has not led me to overstate the case in its favor, but that, on the contrary, in my desire to keep within indisputably safe bounds, I have greatly understated it.

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APPENDIX C.

MAURY'S ESTIMATE OF THE RESOURCES OF THE GULF OF MEXICO AND OF THE CARIBBEAN SEA, AND OF THE IMPORTANCE OF INTEROCEANIC COMMUNICATION.

NATIONAL OBSERVATORY, *July* 2, 1849.

SIR: According to request and promise, I proceed to treat of the Panama Railway, the commercial resources of the Gulf of Mexico, and the probable effect upon the prosperity of the country of a good commercial thoroughfare between the Atlantic and Pacific Oceans.

The opening of a communication across the Isthmus is one of the most important projects of the age. The country is ripe for it, and there are capitalists enough ready to embark in it, provided the Government will hold out to them a fair and reasonable encouragement.

I see by the papers that books were opened the other day in New York for subscriptions to the Panama Railroad, and that one million of dollars of the stock was taken. It is probable that this sum will be applied either to a light road for horse-power, or the construction of a track from Panama 20 miles over to the river Chagres; neither of which plans will subserve effectually the great interests of the country or the purposes of commerce.

Before investing freely or launching out boldly into such an undertaking, cool-headed men desire to see the hand of their Government with them in the work. They desire it not so much on account of the sum to be paid, but on account of the security, the confidence that it would give, to see the Government assuming some sort of pecuniary responsibility with them in the matter. As for the mere matter of dividends, capitalists could make more by first constructing the work on their own account, and then fixing their own terms for services rendered the Government. But in this case there would be wanting the confidence in the work which a subscription to it by the Government, or an offer of reasonable compensation for services to be rendered would impart. If the Government of the United States were to put its hand to the work, so that it should be soon in some tangible shape, either as a subscription or as an annual installment, the mere sight of it would give the world confidence in the undertaking, and this confidence would be worth far more in the eyes of business men than the mere dollars and cents out of the public treasury. If the Isthmus of Panama belonged to some strong and stable power, a railroad or ship-canal there would present one of the most attractive fields for investment that could be presented to capitalists.

Let us take a view of this railroad and our position with regard to it in some of those manifold lights in which the wants of commerce and the great interests of the people of the United States present it. And for this purpose I extract from an article which I have recently written on the subject.

Rightly to do this and properly to estimate the effects which are to arise from uniting the two oceans, it is necessary to pass in review the position in respect both to the Old World and the New, of *our* Mediterranean, which consists of the Gulf of Mexico, with its archipelago, the Caribbean Sea. The geographical position of this sea and its shores, the size of the rivers which flow into it, the climates and soils of their valleys, and the hand with which nature has strewed the elements of commerce among them, all conspire to make it the most useful to the greatest number of men, and, therefore, the most interesting sea in the world. It is situated midway between the two Americas. Rivers whose headwaters reach back north and south into the very heart of the country flow into it. A line from the delta of the Orinoco to the east end of Cuba is but a thousand miles long; and yet to the west of it lies this magnificent basin of water, locked in by a continent that has on its shores the most fertile valleys of the earth. In the midst of these valleys ships may sail thousands of miles on the largest rivers that bring tribute to the ocean. They contain the elements of dormant wealth, of national power and greatness, which it requires facility of communication with the Pacific to begin to develop, and which, when fully developed, will astonish the world. An era and an epoch in the affairs of nations will date from the opening of this communication. All, and more too, that the Mediterranean is to Europe, Africa, and Asia, this sea is to America and the world.

A sea is important for commerce in proportion to the length of the rivers that empty into it, and to the extent and fertility of the river basins that are drained by it. The quantity and value of the staples that are brought down to market depend upon these. The Red Sea is in a riverless district; few are the people and small the towns along its coast. Its shores are without valleys; not a river empties into it, for there is no basin for it to drain. Commercially speaking, what are its staples in comparison with those of the Mediterranean, which gives outlet to rivers that drain and fertilize basins containing not less than one million and a quarter of square sea miles of fruitful lands? Commercial cities have never existed on the shores of the Red Sea. Commerce loves the sea, but it depends for life and health on the land. It derives its sustenance from the rivers and the basins which they drain, and increases the opulence of nations in proportion to the facilities of intercourse which these nations have with the outlets of such basins.

The river basins drained into the Gulf and Caribbean Sea greatly exceed in extent of area and capacity for

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production the river basins of the Mediterranean. The countries in Africa, Asia, and Europe which comprise the river basins of the Mediterranean, are, in superficial extent, but little more than one-fourth the size of those which are drained by this sea in our midst. It is the Mediterranean of the New World, and nature has laid it out on a scale for commerce far more grand than its type in the old; that is about 45° of longitude in length by an average of 7° of latitude in breadth. Ours is broader, but not so long; it is, therefore, more compact; ships can sail to and fro across it in much less time, and gather its articles of commerce at much less cost.

The two seas cover each about the same superficial extent; but from one extreme to the other of that of the Old World the route is tortuous and the voyage long. It cannot be accomplished without sailing a distance quite equal to that between Europe and America; whereas from the most remote point in the Caribbean Sea to the farthest port in the Gulf a straight line may be drawn on the water, and the distance from one extremity to the other of it will be but little more than 2,000 miles.

From the ports of the Levant and Black Sea to the ocean a vessel under canvas requires a month or more, but from any point on the coast of this central sea of America a vessel may be out on the broad bosom of the ocean in a few days. Winds and currents, with all the adjuvants of navigation, are here much more propitious to the mariner than they are in any other part of the world.

There is a system of perpetual currents running from the ocean into this sea, and from this sea back into the ocean. They are literally rivers in the sea, for they are as constant, and almost as well marked, as rivers on the land. Had it been left to man to plan the form of a basin for commerce on a large scale—a basin for the waters of our rivers and the products of our lands—he could not have drawn the figure of one better adapted for it than that of the Gulf, nor placed it in a position half so admirable.

The shores of the Mediterranean are indented by deep bays and projecting points of land, which greatly lengthen the sailing distance from port to port. The sinuosities of short lines add to the expenses of commercial intercourse. By land the distance from Genoa to Venice is only a few hours' travel, but by water they are more than a thousand miles apart. There is no such interruption to navigation in the Gulf of Mexico; the shortest distance from port to port there, as from New Orleans to the ports of Texas and Mexico, to Pensacola, Havana, and the like, is by water.

The windings of the Mediterranean shore line, exclusive of its islands, measure 12,000 miles in length, whereas those of the Gulf and Caribbean Sea do not mete out half that distance. Ships, therefore, which go into the Mediterranean have to gather the produce which is brought down from its river basins, containing less than 2,000,000 square miles, to wind along a coast line 12,000 miles in length, whereas those which go into the Gulf of Mexico may, by sailing 5,000 miles, reach the mouths of rivers that drain of water and surplus produce more than 4,000,000 square miles of fruitful plains and fertile valleys.

Easy access by sea to the mouths of rivers which drain extensive basins of rich land has always been regarded as the best basis upon which the foundations of commerce can be laid. The character and extent of the back country which supplies such outlets are the true exponents of the commercial prosperity of the cities, and the condition of the people who dwell there. The closer these outlets are together, and the greater the diversity of the climates drained by them, the more numerous are their products and the more active is their commerce. Hence the commercial importance of every bay, gulf, and sea of the ocean may be considered as in direct relation to the extent, variety, and fertility of their river basins. Because the Red Sea is in a riverless region, it has no markets; consequently it has, in the eye of commerce, ever been regarded as valueless in comparison to the Bay of Bengal and the Mediterranean Sea, with their broad basins and beautiful tributaries.

Every one, who takes the trouble to examine, is struck with the fact that the greatest commercial cities of the world are and ever have been those whose merchants have been most advantageously situated with regard to the outlets, natural or artificial, of great river basins and producing regions.

Rightly to perceive how admirably located and arranged for the purposes of commerce are the Gulf and Caribbean Sea, and duly to appreciate the advantages arising therefrom, let us, before comparing the river basins of America with those of Europe and Asia, or before tracing further the effects which the course of the rivers of a country has upon its commerce, take a glance at the geographical position of this our central sea.

Curtained on the east by a chain of fruitful islands, stretching from Trinidad to Cuba, it is on the north and the south and the west land-locked by the continent, which has bent and twisted around this sea so as to fold it within its bosom and hold it midway between the two semi-continents of the New World. In this favored position it receives on one side the mountain streamlets of a sea of islands; on another, all the great rivers of North America; and on the others the intertropical drainage of the entire continent. The Atlantic Ocean circulates through this our Mediterranean. Its office in the economy of the world is most important. It not only affords an outlet for the great American rivers, but it makes their basins habitable by giving them drainage and by sending far away into the ocean the drift and the overheated waters which the rivers bring down. It also, through its system of cold and warm currents, makes its own shores habitable to man, tempers the climate of Europe, and by its genial warmth makes productive the soil there. The Amazon, rising in the Andes and emptying into the ocean under the line, also finds its way through the magnificent llanos and pampas of the tropics down to the margin of this sea.

In consequence of the Gulf Stream, the mouth of the Mississippi is really in the Florida Pass. The waters of the Amazon flow through the same channel. The great equatorial current of the Atlantic sweeps across the mouth of this river and carries its waters into the Caribbean Sea; from the Caribbean Sea they flow into the Gulf of Mexico, and thus by the Gulf Stream back into the Atlantic. Such is the channel through which the waters of the Atlantic complete their circuit and are borne back into the ocean again. The distance in a straight line from the mouth of the Amazon to the Florida Pass is only 2,400 miles. Therefore the Amazon may be very properly regarded as one of the tributaries, and its basin as a part of the back country to this our noble sea. The connection is even more close; for

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one mouth of the Amazon is that of the Orinoco, which empties directly into the Caribbean Sea. These two streams present the anomaly of two great rivers having sources in common. A person sailing up the Amazon may cross over into the Orinoco and re-enter the sea through that river without having set his foot on shore or disembarked once. The Rio Negro takes its rise from the eastern slope of the Andes, and after having run several hundred miles, divides itself into two streams, one of which flows into the Amazon, the other into the Orinoco. This is nature's canal between them.

The Mississippi and the Amazon are the two great commercial arteries of the continent; they are fed by tributaries with navigable length of channel more than enough to encircle the globe.

This sea, therefore, is like a heart to the ocean. Its two divisions of sea and gulf perform the office of ventricles. Floating bodies from the region of Cape Horn, from the coast of Africa, and the shores of Europe, are conveyed into the Gulf of Mexico, whence its waters, supplied anew with heat and motion, are again sent forth through their channels of circulation over the broad bosom of the Atlantic. To Western Europe the heated currents of this sea distribute their warmth, and then return back to their sources through the invisible channels of the deep.

We have seen that the river basins of the Mediterranean cover but little more than one-fourth the area which is drained by the streams which empty into the central sea of America. That we may realize the extent of these river basins of America, let us add to those of the Mediterranean the chief river basins of Western Europe and Southern Asia, and see if they can outmeasure the valleys drained by our Mediterranean alone. Before doing this, however, permit me to glance at the geographical features and physical conditions which regulate the size of the river basins to be considered.

It is a remarkable feature in the formation of this continent that there are no great basins in the interior without sea drainage, and no rainless districts of any considerable extent. With one or two exceptions, as the inland basin of the City of Mexico and the Salt Lake, which comprise but small districts of the country, all the water-courses of America empty into the sea. The extent of country for sea drainage here is far greater than in any other part of the world. Hence we have larger valleys, valleys which are longer and broader than any in the Old World. Consequently they collect more water, call for more drainage, and hence give rise to more and larger rivers. In the Old World there is a region of country 80° of longitude by 17° of latitude in extent in which it never rains. Here, between the Andes and the Atlantic, there is no such rainless region. The annual fall of rain between the tropics in the Old World is 6 feet; in the New World it is 11; and it is greater here than there in the temperate zone also. More than one-half of all the fresh water in the world is on the continent of North America. In facts like these is found the explanation as to the cause of the surprising length and volume of many of the American rivers. Big rivers are required to drain broad valleys.

In Europe and Asia the great continental declivities are such as to leave no room for any remarkable length of river or breadth of valley. In North America there is an immense valley between the Alleghany and the Rocky Mountains. The great lakes form the northern edge of this valley, the entire drainage of which is therefore carried off towards the south into the Gulf of Mexico. This is the basin of the Mississippi. In South America the Andes skirt the western coast very closely and send off to the east a chain of mountains from Bolivia to the Atlantic coast of Brazil. These mountains divide South America into two great systems of river basins; the drainage of one is to the north and east, of the other to the south.

In the broadest part of the continent, therefore, which is its northern portion, the continental slope gives rise to the first-mentioned system. The district of country included in it is an immense one, the rains are heavy and the drainage great. Hence the direction and volume of the Para, the Amazon, and Orinoco. The basin which slopes to the south is much less in extent; it is drained by the La Plata.

In one part of Europe the drainage is in all directions towards the Black Sea, which is sunk in a sort of basin of its own, and receives the drainage from several quarters. But the longest slope on the sides of this basin runs up west towards the center of the continent. Here the Danube and other draining streams, which empty into the Black Sea and thence into the Mediterranean, take their rise. On the shores of this last, we have the drainage to the south, which give rise to the Rhone, etc. Europe has its Atlantic slope also, and there the rivers, as the Tagus, the Rhine, and the Elbe, run west. Thus you perceive that the geographical features of Europe leave no room for a hydrological expression like that of the Amazon and the Mississippi, with their valleys.

In the interior of Asia there is a grand continental basin 85° of longitude in length. It is spread out over the middle of the continent, and extending from the borders of Europe to the eastern districts of China, it embraces a region of country more than 4,000,000 square geographical miles in extent, which has no ocean drainage. In the midst of the Old World, it is surrounded by steppes and mountain ranges which shut it out from the world of waters beyond. It gives rise to many large rivers, as the Volga and the Omal; but they empty into the Caspian and other continental seas, which have no visible outlet or communication with the ocean. For all great purposes of commerce this immense and fertile basin is as blank as the desert Zahara. Of course, then, the rivers above this basin must run north into the frozen ocean, which is also a blank as white as snow in the book where commerce records her statistics. These river basins embrace nearly 4,000,000 geographical square miles.

On the south side of this inland basin the inclination of the continental level is towards the China Seas and Indian Ocean. Here, then, we must look for those river basins and the origin of those streams which give rise to the commerce of the east; and here, accordingly, we find the teeming valleys drained by the Euphrates, the Ganges, and the Yangtse-Kiang; all of which descend from fruitful plains, and all except the last are open to trade and traffic with "outside barbarians."

The distance from the Bay of Bengal and Arabian Sea to the southern edge of this great inland basin varies from 3° to 10° of latitude; consequently, the climate through which the rivers of India flow is limited to 10° of latitude. The

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produce that comes down those streams for market has no greater range of climate than that which is due to a north and south line of 500 or 600 miles in length. Neither can the rivers themselves be very long, nor their basins very broad, nor their volume of water very great. Their valleys may vie in fertility with those of the Mississippi and the Amazon, but as for diversity of climate, variety of productions, and navigable capacity of water-courses there is no comparison.

Let us now return to the comparison as to extent of the river basins of the Old World with those under consideration in the New. According to one of the most remarkable works of the age—Professor Johnson's Physical Atlas—the river basins in the Old World contain, in geographical square miles, stated in round numbers, as follows, viz:

	Square miles.
Of Mediterranean, Europe	1,160,000
Of Nile	520,000
Of Euphrates	196,000
Of Indus	312,000
Of Ganges	432,000
Of Irawady	331,000
Of others of India	173,000
Of those of Western Europe, as Rhine, etc	730,000
Total Mediterranean, India, and West Europe	3,854,000

AREA, IN GEOGRAPHICAL SQUARE MILES, OF RIVER BASINS DRAINED INTO THE GULF OF MEXICO AND CARIBBEAN SEA.

	Square miles.
Basin of Mississippi River	982,000
Basins in Florida and Texas (estimated)	520,000
Basins in Mexico and Central America (estimated)	300,000
Basin of Amazon (including basin of Para)	1,796,000
Basin of Orinoco and all others of Caribbean Sea	700,000
Total Gulf and Caribbean Sea	4,298,000
Total Mediterranean, India, and West Europe	3,854,000

Difference—call it nothing, though it measures an area containing nearly half a million of square miles.

From this statement we are led to the very remarkable conclusion—and it is an important physico-commercial fact—that the area of all the valleys which are drained by the rivers of Europe which empty into the Atlantic, of all the valleys that are drained by the rivers of Asia which empty into the Indian Ocean, and of all the valleys that are drained by the rivers of Africa and Europe which empty into the Mediterranean, does not cover an extent of territory as great as that included in the valleys drained by the American rivers alone which discharge themselves into our central sea. Never was there such a concentration, upon any sea, of commercial resources. Never was there a sea known with such a back country tributary to it.

The produce which comes down the rivers of Europe has, when it arrives on the shores of the Atlantic, to be transported 15,000 or 20,000 miles to be exchanged for that which comes from the river basins of India. From the mouth of the European rivers discharging into the Atlantic Ocean the voyage to the mouth of the Asiatic rivers which run into the Indian Ocean often occupies 200 days; consequently, it requires a ship more than a year to take on board a cargo from the river basins of Europe, go with it to India, exchange it, and return with the proceeds thereof to the place whence she started; so great the distance and so long the period of time which separate these two fountains of commerce.

One ship, therefore, trading between the American system of river basins may fetch and carry, exchange and bring back in the course of one year as many cargoes as ten ships can, in the same time, convey between the remote basins of the system in the Old World.

The products of the basin of the Mississippi, when they arrive at the Balize, may in twenty or thirty days be landed on the banks of the Orinoco and the Amazon. Thus, in our favored position here in the New World, we have, at the distance of a few days' sail an extent of fruitful basins for commercial intercourse which they of the Old World have to compass sea and land and to sail the world around to reach.

On this continent nature has been prodigal of her bounties. Here, upon this central sea, she has, with lavish hand, grouped and arranged in juxtaposition all those physical circumstances which make nations truly great. Here she has laid the foundations for a commerce the most magnificent the world ever saw. Here she has brought within the distance of a few days the mouths of her two greatest rivers. Here she has placed in close proximity the natural outlets of her grandest river basins. With unheard-of powers of productions, these valleys range through all the producing latitudes of the earth. They embrace every agricultural climate under the sun; they are capable of all variety of productions which the world besides can afford. On their green bosom rests the throne of the vegetable kingdom. Here commerce, too, in time to come, will hold its court.

The Mississippi comes down from the grain-producing regions of the north, bearing vessels deeply laden with produce; freighted with all varieties of the fruits of the temperate zones, they convey to the sea large cargoes of merchandise, gathered from the products of the field, the forest, and the mine. Hills of iron, mountains and valleys filled with coal, are found on its banks. Its waters are mingled in the Gulf with those of the Amazon and the Orinoco, which run between the tropics. From their basins they are ready at the bidding of civilized man to place on this sea, in all variety and abundance, the products of the torrid zone.

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Arrived in the Gulf with these goods, the mariner then finds a river in the sea to speed him on with its favoring currents to prosperous voyages. Through the Gulf Stream the productions of this grand system of river basins will be distributed over the world, passing by, and enriching as they go, Norfolk, Philadelphia, New York, and Boston, all the Atlantic slope of the United States, and all the Pacific slope, too.

From 50° north to 20° south, the Mississippi and the Amazon take their rise. A straight line from the headwaters of one to those of the other measures a quadrant of the globe. They afford outlets to all the producing climates of the earth. Upon this gulf and sea perpetual summer reigns; and upon their shores climate is piled upon climate, production upon production, in such luxuriance and profusion that man without changing his latitude may in one day ascend from summer's heat to winter's cold, gathering, as he goes, the fruits of every clime, the staples of every country. To gather such things in the Old World, commerce must first plume her wings and sail in search of them through all latitudes and climates, from the extreme north to the farthest south. In the small compass of the West India sea are crowded together the natural outlets of the ocean, from mountains, plains, and valleys, that embrace every variety of production, every degree of latitude and climate, from perpetual winter to eternal spring. The largest water-courses of Europe and India do not run through more than 10 or 15 degrees of latitude. The greatest variety of climate possessed by the river basins of India, the Mediterranean and Atlantic Europe, is included between 10° and 55° north latitude; only 45 degrees of latitude there against 70 degrees here. There they are all in the same hemisphere, and when it is seed time in one basin, it is seed time in all, and a short harvest there produces famine. Here, in the American system, we include both hemispheres, and therefore when it is seed time in one basin it is harvest in the other. With this blessed alternation of seasons so near at hand and so convenient to our great seaport towns and avenues of trade, famine on these shores is impossible. With this American sea between the two hemispheres, and in the lap of both, nature has endowed it with commercial resources and privileges of infinite variety.

Here come together and unite in one the natural highways to the ocean, from mountains, plains, and valleys, teeming with treasures from the mineral, the vegetable, and the animal kingdoms—nature's most princely gifts to man.

Were it given to us of this day to look down through future generations and to see the time when the valleys of the Mississippi, the Orinoco, and the Amazon shall be reclaimed, peopled, and cultivated up to their capacities of production, we should behold in this system of river basins and upon this central sea of ours a picture such as no limner can draw, no fancy can sketch. All the elements of human greatness which river, land, and sea can afford are here crowded together; for their full development easy access to the Pacific is necessary.

The course of a river exercises important bearings upon commerce. A river that runs east and west has no diversity of climate; its basin is between two parallels of latitude, and there is no variety of production from source to mouth, except such as is due to elevation. The husbandman who inhabits the banks of such a stream when he descends it with his surplus produce for exchange and barter, finds on his arrival at its mouth that he has come to Newcastle with coals only. He is there offered duplicates in exchange for what he has brought to sell; all sellers and no buyers never can make commerce brisk. Such a river may have a staple; it may be corn, it may be oil; but whatever it be, it is all they who dwell in its valley have to sell; and whatever they buy, they buy with that staple. The commerce of such a basin, therefore, must be with other latitudes, with other climates, and with regions which afford *variety*.

On the contrary, one who descends a river that runs north and south, finds his climate changing day by day; at every turn new plants and strange animals meet his eye. He brings with him from its headwaters the furs, the cereal grains, and a variety of articles (productions of the north) to exchange for coffee and sugar and the sweets of the south, which are gathered on its banks below.

It is the business of commerce to administer to the fancies as well as the necessities of man; she therefore delights in variety of climate and assortments of merchandise. It is owing to the diversity of climate and production afforded by the States of this Union and to the facilities of intercourse with them that the trade of a single State, as Massachusetts, with the rest, exceeds in value the entire foreign commerce of the whole country with all the world besides. The pursuits of commerce abound in secrets of high import to the happiness of man; an easy communication from the Gulf to the Pacific is the key to some of them.

"As the external face of continents," says Humboldt, "in the varied and deeply indented outline of their coasts, exercises a beneficial influence on climate, trade, and the progress of civilization, so also in the interior, its variations of form in the vertical direction, by mountains, hills and valleys, and elevated plains, have consequences no less important. Whatever causes diversity of form or feature on the surface of our planet-mountains, great lakes, grassy steppes, and even deserts surrounded by a coast line margin of forest, impresses some peculiar mark or character on the social state of its inhabitants."

Our lofty mountain chains and majestic water-courses have served, according to the same great philosopher, to furnish a more beautiful and rich variety of individual forms, and to rescue the face of the continent from that dreary uniformity, which tends so much to impoverish both the physical and intellectual powers of man.

Had the Missouri River, after taking its rise under the Rocky Mountains and uniting with the Mississippi, held its course eastward until their waters were emptied into Long Island Sound, how different would have been the present condition of these United States; had the drainage of the country been in this direction, the Gulf of Mexico would have been as a stagnant pool, and we should have been as indifferent to New Orleans and the purchase of Louisiana, as we now are to Merida and Yucatan. Because the Mississippi River runs from north to south, it is one of the strongest of the bonds which hold this Union of States together.

All the great rivers of the United States lie wholly within the temperate zone. Their basins are spread out

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under climates which call for the highest energies of man. Dwelling in such regions, he is constrained to be diligent; to labor; to be prudent; to gather into barns; to study the great book of nature; to observe her laws; and, whilst it is summer, to take thought for the winter.

The perpetual summer of the tropics presents no such alternatives. On the same tree may be seen the bud, the flower, and the ripe fruit. Here, therefore, nature urges no such necessities, imposes no such tasks, and savage man is as careless of the morrow as are the lilies of the field. The people of the two climates are, therefore, different. Frequent intercourse between them will improve the character of each, and the most ready channels for such communication are afforded by the rivers that run north or south. With the exception of the Nile, the general direction of all the rivers of Africa is east or west; and not one of their valleys, except the valley of the Nile, has ever been the abode of civilized man.

Civilized society cannot be stationary. Vacuity is not more abhorrent to nature than is a state of rest, either in the moral or the physical world. The materials of the latter she has divided into ponderables and imponderables, and invested them with antagonistic principles. By the action of light, heat, and electricity upon ponderable matter "the morning stars were first made to sing together," the earth is clothed with verdure, the waves lift up their voice, and the round world is made to rejoice. She has divided the former into animal and spiritual, and they are antagonistics—the one elevating, the other depressing man in the scale of being. When his course ceases to be upward and onward, the spirit yields to the animal; virtue gives way to vice; the force of evil prevails, and the course of men in their social state is no longer onward and upward, but backward and downward. The sphere that lags behind in its course is hurled from its orbit. History bears witness to the fact that when nations cease to rise they begin to fall. The laws of nature are her agents; they cannot act and be still; action implies motion; nature herself is all life and activity; she knows no rest, brooks no pause, either for her moral or her physical agents. Wise men say she has attached a curse to standing still. This is German philosophy; but the idea is beautiful, because it is true. We want the stimulants to energy, the incentives to enterprise which a highway across the Isthmus is to give, to urge men to the high destinies which await us. The energies of the country are great; they require highways to the Pacific to give them scope and play.

On account of this central sea, and its system of winds and currents; on account of the course of the rivers which run into it, and the direction of the mountain ranges that traverse the continent; and on account of the character and extent of the river basins and other geographical features with us, the Old World affords no parallel, either in history or example, by which to judge of the destinies of this country. Our mountain ranges are longer, our rivers are more majestic, our valleys are broader, our climates are more varied, our productions are more diversified here than they are there.

The wheat harvest on the Lower Mississippi commences in June, and in the upper country Christmas is at hand before the corn crop is all gathered in. Thus we have in the valley of this majestic water-course a continued succession of harvests during more than half the year. In the other hemisphere the seasons are reversed; and on the banks of the southern tributaries to our central sea, reapers are in the field during the remainder of the year. A sea which is the natural outlet to the market of the fruits of regions where seasons are reversed and the harvest is perennial is nowhere else to be found.

Such advantages, both moral and physical, such means of power, wealth, and greatness as have been vouchsafed to us, no nation has ever been permitted to enjoy. We have already more works of internal improvement, a greater length of railroad and canal, built and building, and of river courses open to navigation—more of the buds and blossoms of true greatness than all the world besides. In these facts we see the effect of geographical features, as well as of free institutions.

As a general rule, our railroads and rivers are at right angles in their courses. In the New England States, where the rivers run south, the railroads run east and west; in the Middle and Southern States, where the water-courses run eastwardly, the railroads take a more northwardly direction. Rivers run from the mountains to sea; railroads run across the mountains. They go from valley to valley.

In calculating the sources of the national wealth, prosperity, and greatness which are contained for this country in river basins, central sea, mountain ranges, water-courses, and geographical features, the lights of history are of no avail. You may prepare the canvas and make ready the easel, but colors that are bright enough for the features cannot be found. The exceeding great resources of our Mediterranean beggars description. We know that other places with the elements of commerce in far more scanty proportions, with facilities less abundant, and obstacles far greater, have grown opulent and obtained renown in the world. While one calls to mind the history of such places, he feels that here is room and scope enough for individual wealth far more dazzling, for national greatness far more imposing, and a renown far more glorious.

From all this one is led to the conclusion that the time is rapidly approaching, if it have not already arrived, when the Atlantic and Pacific must join hands across the Isthmus. I have shown that there is no sea in the world which is possessed of so much importance as this southern sea of ours; that with its succession of harvests there is, from some one or other of its river basins, a crop always on the way to market; that it has for back country a continent at the north and another at the south, and a world both to the east and the west. I have shown that it is contiguous to the two first, and convenient to them all. The three great outlets of commerce, the delta of the Mississippi, the mouths of the Hudson and the Amazon, are all within 2,000 miles—ten days' sail—of Darien. It is the barrier which separates us from six hundred millions of people—three-fourths of the population of the earth. Break it down, therefore, and this country is placed midway between Europe and Asia; this sea becomes the center of the world and the focus of the world's commerce. Open this as a highway, and you will give vent to commerce, scope to energy,

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and range to enterprise, which in a few years hence will make gay with steam and canvas parts of the ocean that are now unfrequented and almost unknown. Old channels of trade will be broken up and new ones opened. I greatly desire to see our country the standard-bearer in this great work.

The railroad across the Isthmus of Panama will speedily lead to the construction of a ship-canal between the two oceans, for a railroad cannot do the business which commerce will require for it; and by showing to the world how immense this business is, men will come from the four quarters to urge with purse and tongue the construction of a ship-canal.

The two shores of the Atlantic have been brought nearer together by means quite different from those proposed for uniting the Atlantic and Pacific Oceans. In both cases there is a saving of time, with increased facilities of commerce. The Atlantic has been narrowed so as to practically bring America within two weeks of Europe, instead of having them as many months apart, as they formerly were. Whether this has been done by railroad or canal, or by the improvements of the age and the enterprise of man, the effect, so far as the saving of time and the advantages to intercourse resulting therefrom, is the same.

Now let me call to your mind the benefits that our people and the world have derived in consequence of bringing the two shores of the Atlantic closer together, that you may better judge as to the effects of the proposed connection with the Pacific.

Rightly to appreciate these benefits, which it required ages to bestow, it is necessary to contrast our present condition with what it would have been under the old state of things, when "coward commerce" crept along the frightful shores and scarce had nerve or strength of wing to venture out upon the blue water; when ships were tubs at sea that found it as much as they could do to average fifty miles a day, even under a press of canvas; when, for want of roads and canals, the fruits of the earth could only with great difficulty and expense be conveyed to market. Less than two hundred years ago the roads in England were so bad, the difficulties of communication so great, that entire crops were sometimes suffered to rot in one place, while in another place, distant only a few miles, the supply fell far short of the demand.* No marvel, then, that plagues, pestilence, and famine were common in those days, and that great nations were eager to have access by sea to the mouths of large rivers; for navigable rivers were, and still are, the most ready channels for conveying the surplus product of their basins to market. What would the commerce of the country now be worth, what would its maritime consequence, its wealth, its power, its greatness now be, in comparison to what they are, had the passage of the Atlantic been as tedious, the difficulties in navigating it as great, and the obstacles in the way of trade and commerce as formidable now, both by land and water, as they were a century back? The very causes which have contributed to remove them and shorten the passage across the Atlantic are so important, by reason of their effects upon the condition of men and nations, that the great Humboldt, in his admirable Cosmos, considers them as constituting an epoch in the history of the *universe*.

According to him, the discoveries and improvements of navigation, the use of the compass, the variation of the needle, the log, chronometers, the means of determining the place of the ship at sea, improvements in shipbuilding, the introduction of steam in ocean navigation, and the like, ought all to be regarded as exerting a favorable influence in bringing within the reach of civilization and the Christian religion all parts of the earth's surface, and in shaping the fortunes of men—the destiny of nations. These causes have been ages in producing their effects, and the epoch is spread over centuries; the obstacles which ignorance and prejudice, the trammels which unwise laws and blighting monopolies place in the way of commerce had all to be removed before the passage of the Atlantic could be narrowed down to its present limits. But here the means are different; a continent is to be cut in twain, and the four quarters of the globe are brought in closer proximity *per saltum*. The task is easier; the people are ripe for it; the husbandman who supplies commerce with her staples is enlightened and free; mechanics are all-powerful with their achievements; the principles of free trade have gained strength; the blossoms of civilization, sheltered by wise laws and free institutions, have unfolded themselves vigorously; everything but Congressional action conspires to make the work easy.

Progression and improvement are the order of the day. Instead of throwing obstacles in the way of commerce, the spirit of the age demands for it every facility that is calculated to promote friendly contact and free intercourse among nations. Great revolutions in trade are to follow the separation of the two parts of the continent, whether by railroad or ship-canal. Let us consider some of the most obvious results, but by no means, therefore, the most important, that are to arise from it. At present the whale fishery is the most important branch of business which the citizens of the United States carry on over the waters of the Pacific. The floating capital annually employed in it does not fall much short of fifteen millions of dollars.

It so happens we have cruised over the Pacific for a number of years, that we have seen much of whalers, and enjoyed rare opportunities for obtaining statistics and other information touching this interest. Here is some of it:

According to the Whaleman's Shipping List of January 9, 1849, published at New Bedford, there are, at this time, out upon the high seas a whaling fleet of six hundred and thirteen sail, carrying in round numbers 200,000 tons.

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*Macaulay's History of England.

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We subjoin a comparative statement, drawn from the same authority, as to the quantity of bone and oil (sperm and right) imported for the last nine years:

Imports for—	Sperm oil.	Whale oil.	Bone.
	Barrels.	*Barrels.*	*Pounds.*
1848	107, 976	208, 856	2, 008, 000
1847	120, 753	313, 150	3, 341, 680
1846	95, 217	207, 493	2, 276, 939
1845	157, 917	272, 730	3, 167, 142
1844	139, 594	262, 047	2, 532, 445
1843	166, 985	206, 727	2, 000, 000
1842	165, 637	161, 041	1, 600, 000
1841	159, 204	297, 348	2, 000, 000
1840	157, 791	207, 908	2, 000, 000
Total for nine years	1, 271, 171	2, 047, 300	20, 926, 206
Average for nine years	141, 242	235, 456	2, 324, 578

The present value of sperm oil is $1.40 per gallon, but usually about $1, equal to $32 per barrel; the value of whale oil, $10.50 per barrel; and of bone, 33 cents per pound; equal to $4,519,744 for the average of sperm, $2,472,288 for whale, and $367,110 for bone; total, $7,356,142 annually fished up out of the sea. This is a sum far greater than that which is annually gathered for commerce out of all our magnificent forests.

We are not able to state the precise number of vessels employed in the Pacific, or how much of this seven millions and a third should be credited to that ocean, though in 1846 there were two hundred and ninety-two vessels fishing on the northwest coast alone, and they took while there 253,500 barrels of oil. We may safely assume that two-thirds of the whole number of vessels engaged are employed in the Pacific, and that three-fourths the oil taken comes thence, for the vessels in the Pacific are larger than those in the Atlantic fishery. This would give for the Pacific, in round numbers, four hundred vessels, yielding annually five millions and a half of money.

The cost of outfit and vessels for this fleet is about $28,000 per vessel; the average length of a voyage (mean of right and sperm whalers) is three years, of which one-third is lost in going and returning from whaling grounds, laying in port to recooper, refresh, etc., leaving but two years of actual fishing, or eight months in twelve. The rate of insurance upon vessels and outfits is 3 per cent. per annum, and the legal interest upon the money invested in ships and outfits, which make no return until the end of the voyage, is 6 per cent. The loss of oil by leakage is 5 per cent. during the voyage.

Now, Panama is on the confines of one of the most valuable whaling grounds in the Pacific. In that vicinity and near the Gallapagos Islands the sperm whale resorts in large numbers, and if a railroad or ship-canal were constructed across the Isthmus, it would vastly benefit this interest, in which there is a floating capital greater than that employed in all our commerce with China and the ports and countries bordering on the Pacific and Indian Oceans put together.

If this oil, then, instead of remaining on board the vessel from one to two years (for that which is taken the first year remains on board two years, and that which is taken the second, one year) as dead capital, could be sent home across the Isthmus at reasonable tolls, the gains would be great, for there would be a saving both of time and substance; the leakage would amount to but 1 per cent. instead of 5; half the time, at least, that is now employed in consequence of having to desert the whales to cooper the oil, refit, and refresh would be saved; the whaling year might be made to consist of ten instead of eight months, with, of course, a proportional increase of profits on the original outlay for additional two months of fishing; the vessels employed in the business, instead of being large ships, capable of holding 2,800 barrels—the proceeds of three years—would be small ships, capable of holding only one year's gathering; and the cost of smaller vessels, say one-third the size of those now employed, instead of running up to $28,000 each for vessel and outfit, would, by a liberal estimate, be brought down within half that sum. Estimating the charge per ton for storage, freight, and handling at the enormous rate of $20, or $2 per barrel, across the Isthmus (this is 20 cents per ton per mile over railroad), and the freight thence to the United States to be $1 per barrel, or $10 per ton, the following comparative statement is obtained, in illustration of the importance to this interest alone of such a communication:

COST, OUTFITS, AND EXPENSES OF VESSELS ON A THREE YEARS' WHALING VOYAGE IN THE PACIFIC OCEAN.

Cost of four hundred vessels of 2,800 barrels, at $28,000	$11,200,000
Six per cent. interest on same for one year	672,000
Three per cent. insurance on same for one year	336,000
Ten per cent. wear and tear on costs and outfits	1,120,000
Two years' interest on $1,833,333, being one-third of the value of the oil taken during three years, of which one-third is kept on board ship, dead capital, for two years	220,000
One year's interest on oil taken second year	110,000
Leakage, being 4 per cent. on $5,500,000	220,000
Annual average disbursement per ship, $2,000	800,000
Original outlay and expenses for one year's whaling in the Pacific	14,678,000

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CREDITS AND RECEIPTS.

Value of vessels and outfits after one year's wear and tear	$10,080,000	
Value of cargoes returned	5,500,000	
		$15,580,000
Gross profits		902,000

Per contra: Suppose a communication across the Isthmus, and the whaling business to be revolutionized by the substitution of vessels of one-third the present size and half the cost, and by sending the oil home once a year:

Cost of four hundred vessels of 933 tons, at $14,000	$5,600,000
Six per cent. interest on same for one year	336,000
Three per cent. insurance	168,000
Ten per cent. wear and tear	560,000
Annual disbursements per ship, $1,000	400,000
Loss by leakage, 1 per cent. on $6,875,000	68,750
Freight, etc., over railroad, of 48,240 tons, at $20 per ton	970,800
Freights thence home, at $10 per ton	485,400
Original outlay and expenses of whaling one year, and sending proceeds home by Panama railroad	8,588,950

CREDITS AND RECEIPTS.

Value of vessels and outfits, deducting one year's wear and tear	$5,040,000	
Value of bone and oil collected by fishing ten months instead of eight months	6,875,000	
		11,915,000
Gross profits via railroad		3,326,050
Gross profits around Cape Horn		902,000
Margin in favor of the Panama Railroad, on account of the whaling business		2,424,050

Two millions and a half is a large margin, but there is room for a larger margin. Whether the national wealth would be increased to the full extent of it or not, it is evident from the exhibit that the communication in reference to this one interest alone is of sufficient national importance and magnitude to command the most attentive consideration. The prospect of gain is, to say the least, inviting.

It has been the policy and practice of the United States, acknowledged at an early day, and carried out for many years, to encourage nurseries for seamen; with this view, bounties are given to the cod and mackerel fishermen, and the sum paid them from first to last as "fishing bounties" would be quite sufficient to lay double tracks of railroad across the Isthmus. The whale fishery is by far a more valuable nursery than those of the Grand Banks of Newfoundland for seamen, and it has never received any bounties or direct encouragement whatever. It has been left very much to itself. You recollect the fact, and I mention it in this communication with some feeling of pride, that "Old Ironsides" and the "United States," in the last war, were both manned and fought principally by Marblehead men—New England whalemen they were.

Other great interests of state, no less than this, require such legislation as the Constitution allows, and is necessary to insure the early completion of this road.

Mexico is protecting the manufacture of coarse cottons, known as *tucuyas*, and is seeking by this means to make Guadalajara her Lowell. Formerly the raw material from this country was sent around Cape Horn. Cotton is indigenous to Peru. There it bolls and opens all the year, and our merchants have discovered, by encouraging the Peruvians in the cultivation of this staple, it is their interest to send other cargoes in their ships around Cape Horn, exchange them for the cotton of Payta and Lambayeque, and take that to Guadalajara. During the last year, 10,000 bales were taken from these two ports by American ships alone to Mexico. This is quite as great as the exports of cotton from the United States were fifty years ago, and the demand is on the increase. It is dangerous to foster in a foreign country any rivalry, however humble in the beginning, to great national staples. The freight on cotton around Cape Horn is $25 the ton; with this Panama railroad it would be from New Orleans less than one-third that sum.

Costa Rica, on the Pacific, produces sugar and the finest coffee. They are exported to Chili and Peru. The voyage around Cape Horn, and other conditions of commerce, exclude them from our markets. A railroad across the Isthmus would bring New Orleans within two weeks of these coffee and sugar plantations. Thus it would bring a new market into competition with the coffee of Brazil and the sugar of the West Indies.

I have investigated the subject of freights around Cape Horn, and have collected statistics, that I might form an opinion as to the probable cost of transportation of merchandise via Panama railway and via "the Horn" to the ports of the Pacific—say to Lima in Peru. I have supposed the freight over the Panama road will be at least double the usual rates in this country, and have taken it at 10 cents per ton per mile. The conclusion is that a cargo of mer-

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chandise can be sent from New York via Panama to Lima in one-fourth the time and for less than half the money it now takes to send it around Cape Horn.

Here are the facts, the statistics, and estimates from which this conclusion is drawn. The sailing distance from New York to Lima, via Cape Horn, is 13,000 sea miles; the time, four months; the freight, $15, or 1.15 mills per ton per mile. The distance via Panama, exclusive of the 45 miles of railroad, is 3,700* miles, and the time thirty days. The average value of a ton of merchandise is supposed to be $250, on which three months' interest is charged for the excess of the Cape Horn passage.

COMPARATIVE STATEMENT AS TO THE COST OF FREIGHT PER TON FROM NEW YORK TO LIMA.

Via Cape Horn, 13,000 miles, at 1.15 mills		$15 00
Interest on $250 for three months, at 6 per cent		3 75
		18 75
Via Panama, 3,700 miles	$4 25	
Forty-five miles of railroad, at 10 cents	4 50	
		8 75
Difference in favor of railroad		10 00

There are 8,000,000 people inhabiting the Pacific coast. All of them want things we have to sell. They are four or five months removed from us; this road would bring them within thirty days. For those of them who travel, the route to California and China would be across the Isthmus this way to New Orleans, thence up the Mississippi to the California railroad. This, when opened, will be their shortest and best traveling route to California, China, and India. And unless both the California and the Panama routes be established, the line of travel between the Pacific shores of North and South America never can be brought through the United States. These two roads are links on the same line, and when once completed the world cannot prevent all the South American travel from coming this way.

We see cities and states pushing forward rival schemes of internal improvements, setting up opposition after opposition to bring travel their way; they consider themselves rewarded when they secure the business between places containing a few thousand people engaged in traffic. This Panama improvement would bring us the travel from countries inhabited by millions, and send it through the length and breadth of the land, dispensing national, sectional, and particular benefits all the way. The advantages that business and travel scatter on the wayside of their great thoroughfares are and ever have been the objects of desire with the greatest nations, as well as with the smallest corporations. Here they are offered to us on a scale grand in proportion to the watercourses, mountain ranges, lakes, and river basins of the New World, and sublime in proportion to its free institutions. The railroad will build a ship-canal across the Isthmus of Panama upon the same principle that one internal improvement begets another. How many railroads has the Erie Canal caused to be built that but for that improvement would not be in existence? In the same way the Panama Railroad will stimulate commerce with the Pacific, and by showing the amount of business to be done, men of business will see and be satisfied that the road is insufficient and a ship-canal necessary.

Owing to the course of the winds, the direction of the currents, and other physical circumstances, British merchants are ten days' sail and upwards nearer than we are to all the markets of the world, except those of the Caribbean Sea and Gulf of Mexico. They are next door to all the markets of Europe, to Brazil, to Cape Horn, the Cape of Good Hope, and consequently to all ports beyond them they are practically some ten or fifteen days' sail nearer than we are. A vessel from the United States, bound for the southern hemisphere, first sails nearly an east course until she arrives in the vicinity of the Azores and Canary Islands; she then puts her head south for the first time. Now, while the American vessel is sailing this route the English vessel that sailed on the same day for the same market has passed those islands and is far on her way. For the reason that the Cape de Verde Islands are some ten or fifteen days nearer to England than to America, England is that much nearer to the southern hemisphere; for vessels generally, whether from the United States or from England, are in the habit of passing by these islands on their way thither. Therefore, the Englishman meets the American in all the markets of the world, except those of the Gulf and the Caribbean Sea, with the advantage of ten days and upwards.

Notwithstanding this disadvantage, the United States in their commercial race with England have for the last fifty years been gradually gaining. They have been coming up all the time, and at last the contest has become so close that England is hardly a throat-latch ahead. Cut through this Isthmus, "Uncle Sam" will then turn the corner, and England will be distanced. Instead, then, of meeting us in India, China, and even on our own Pacific coast with the advantage of some ten days' sail, or more, the scales will be turned, and we shall have the advantage of some twenty or thirty days, thus making a difference in our favor of thirty or forty days under canvas.

Do you doubt, can any one doubt, as to the effect of a communication which would produce such a change as this in the commercial position of the two countries?

In this point of view alone a communication across the Isthmus is a subject of great national importance, for it would place the Atlantic and Gulf ports of the United States right on the wayside of the great commercial thoroughfare to India and China and all the markets of the Pacific.

Respectfully, etc.,

M. F. MAURY.

Hon. JOHN A. ROCKWELL, M. C.

*3,700, which is less than the distance by canvas from Charleston to Liverpool.

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Chart of Greytown Harbor, showing the direction and extent of the movement which resulted in the destruction of the harbor.

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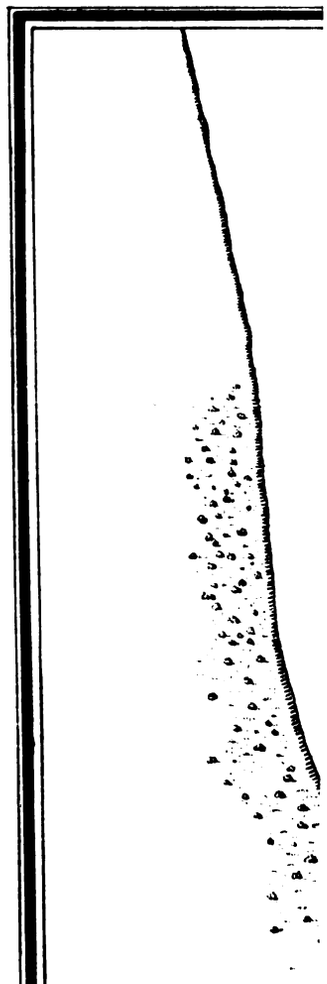

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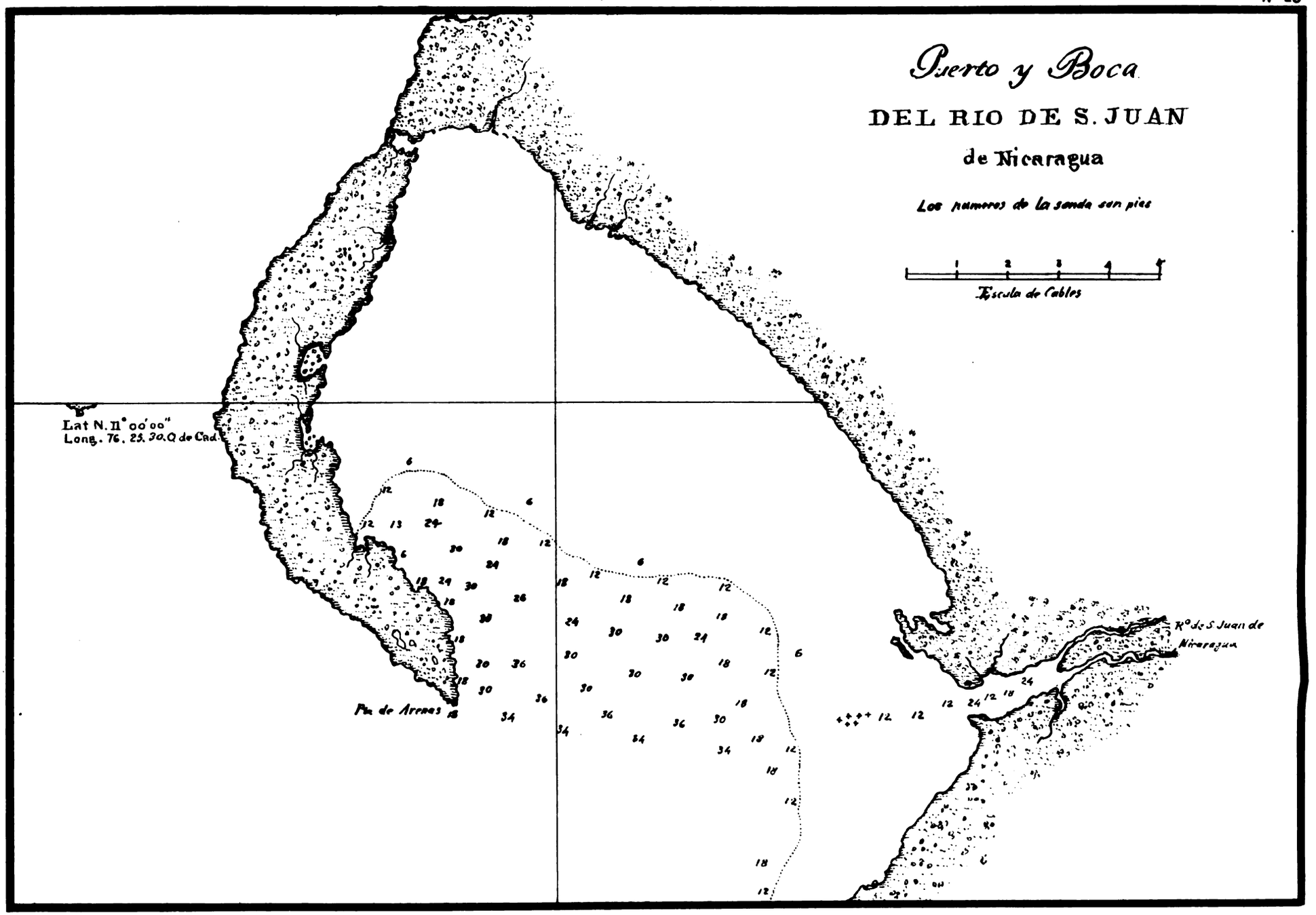
Puerto y Boca
DEL RIO DE S. JUAN
de Nicaragua
Los numeros de la sonda son pies
1 2 3 4 5
Escala de Cables
Lat N. 11° 00' 00"
Long. 76. 25. 30. O de Cad.
Pta de Arenas
R° de S. Juan de Nicaragua

From the "Portulano de la America Setentrional, construido en la Direccion de trabajos hidrograficos, dividido en quatro partes. Madrid 1809," and identical with Chart N° 27 in the same Atlas "aumentado y corregido en 1818" and with Chart N° 27 published in the "Portulano de la America Setentrional dividido en quatro partes. Publicado por Orden del Escmo Sor D. Guadalupe Victoria Primer Presidente de la Republica Mexicana Mexico 1825.

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APPENDIX D.

[From United States Coast Survey Report for 1874.]

APPENDIX No. 12.

REPORT ON AN INSPECTION OF THE TERMINAL POINTS OF THE PROPOSED CANALS THROUGH NICARAGUA AND THE ISTHMUS OF DARIEN, BY PROFESSOR H. MITCHELL, UNITED STATES COAST SURVEY.

GREYTOWN (SAN JUAN DEL NORTE).

The examination of the coast in the immediate neighborhood of Greytown and the outlets of the Lower San Juan River has satisfied me that a reconstruction of the harbor is practicable. This conclusion is based upon a particular conception of the causes which led to the destruction of the old port, and a conviction that these causes, still active, may be successfully resisted by artificial works. I quote the following from the Report of the Committee of the National Academy, made in 1866:

History of Greytown Harbor.—"The earliest source of information that we feel warranted in using is the sketch to be found in Mr. Molina's work upon Costa Rica, which is based upon a survey by George Peacock in 1832, and has additions showing the progress of the sands of Isla Castilla down to 1848.

"In 1832, five fathoms of water could be carried from sea to a point within the present basin of Greytown Harbor, through an opening which measures 1¼ miles from Isla Castilla to the west shore. At that time the avenue to the sea was *without a bar*, and the regular decline of the bottom along the seaward channel-way gave no indications of the action of scouring forces. There was *no depression* at the harbor's mouth and no *accumulations* beyond that seemed in any way to be a dependency upon the existence of the basin or its outlets. The shallow ground lying along the coast outside of Isla Castilla, and projecting beyond to the westward, would seem, upon Mr. Molina's sketch, to be a concomitant or parallel to this island as well as an outwork of the advance. Subsequent surveys, however, dissolve this apparent connection and relation.

"The embouchure of the Lower San Juan River is found in this first survey at the head of the anchorage basin, and the deposits of that stream appear to be nearly two miles within the harbor's mouth.

"Between 1832 and 1834 a movement of the sands to the westward occurred, which extended the point of Isla Castilla about 456 feet per annum. This extension took the form of a hook. From 1834 to 1835 the point advanced 608 feet. Four years later, in 1839, it was found to have advanced 1,065 feet, or at the rate of 266 feet per annum. Between 1839 and 1840 it advanced about 400 feet. Between 1840 and 1848, a space of nearly eight years, it advanced 221 feet per year, and in the next succeeding ten months 913 feet were added, or the beach grew at the rate of nearly 1,100 feet per annum. The harbor as a protection to shipping had been improving up to the last date upon Mr. Molina's sketch, but its opening from the sea had become reduced to about 0.8 of a mile, a loss of over 50 per cent.

"In 1853, we find the mouth of the harbor, measured upon the same line as before, reduced to 0.52 of a mile, a reduction of 35 per cent. since 1848. In this period of four and a half years, the sand-spit made an average annual advance of 401 feet. The physical character of the harbor had thus far undergone no change; the same good depth of water could be carried in; the same gradual decline of the bottom to seaward was preserved, and no bar or shoal lay in front. The point of Isla Castilla called on this more recent map Punta Arenas, had been made across the floor of the sea by sands thrown in from above, not scoured from the bottom; it was built out like a mole, the material taking nearly its natural slope, and not suffering waste under the action of any currents from within. In this chart of 1853, an opening through the beach is found about at the extremity of the Castilla of 1832. As a physical feature it does not yet seem important.

"The survey of 1856 found the dry portion of Point Arenas advanced nearly due south from its position in 1853, and a gradual shoaling-off to the westward, reducing the harbor's mouth to 0.3 of a mile. At this time the point was broad and hooked. The same depth of water could be carried in as formerly, and no bar was found outside.

"Between October, 1856, and January, 1859, two and a quarter years, Point Arenas advanced to the southwest 1,156 feet, or at the rate of about 514 per annum. Even as late as 1859, when the harbor's mouth was reduced to 0.13 of a mile, the only trace of any action from within was the retreat of the 18-feet line on the west shore.

"According to a note upon the British chart, the entrance was reduced to 300 feet in 1861; while, in January, 1865, Captain Jones, of Her Majesty's ship Shannon, reports that the entrance has a bar across it after a norther,

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though after a continuance of fine weather the scour of the river increases the depth to 8 or 10 feet. The passage on the opposite side has also reduced to 50 or 60 yards.

"Our final authority is the survey made under the direction of Captain P. C. F. West, who brought to the field the skill and accuracy of long experience in the Coast Survey, to which corps he now belongs.

"In this survey, made in February, 1865, the change in the physical character of the harbor, shadowed forth in the note that we quoted from the British chart, is confirmed. The anchorage has become a lagoon, with an uncertain *inlet*. Between Point Arenas and the opposite shore a depression of 20 feet is found, to reach which 17½ feet must be passed in the approach from the harbor and 8 feet in the approach from the sea. Here we have the *depression at the opening* and the *bar outside*, which are the characteristics of a true *inlet*, for which we have looked in vain upon the earlier charts.

"After the completion of the general survey, Captain West's party found, in May, that the opening at Greytown Harbor had closed, and that a breach had been made farther to the westward."

Causes of the decline and final destruction of the harbor.—The quotations which I have made from the report of the Academy indicate somewhat the view entertained by the committee regarding the causes which formed and ultimately destroyed the harbor; but I may be permitted to restate the matter briefly from a review of other portions of the same report.

The harbor of Greytown was originally a re-entrant angle or cove, lying between the delta of the San Juan River and the adjacent coast to the northwestward. Near the head of this cove there entered an offset of the San Juan River (bearing the name of the parent stream originally, but recently, for distinction, called the *Lower* San Juan), which formed a subsidiary delta of its own within the cove.

This cove, opening to the northward, was in the course of time converted into a lagoon by a mole of sand driven across the mouth by the waves from the northeastward, which swept past the outer shore of the main delta. It became a harbor easy of entrance and perfect in shelter at the intermediate stage, when the mole had reached within a couple of miles of the main shore to the westward, at which time the channel way from the basin to the sea was in nowise dependent upon the outflow of the Lower San Juan, nor upon the tides, but was simply an avenue, not yet encroached upon, whose bed was the original floor of the ocean. It was not until the mole had nearly crossed to the opposite shore that the river outflow and the tides began to act upon the bed and banks of the outlet, resisting the absolute closure of the basin.

Opposed to the view of the case stated above is another, quite different in character, which has been urged by nearly all the engineers who have visited Nicaragua, and is not to be ignored, because, if it is the correct view, it materially alters the question of the practicability of a restoration, or, at all events, modifies the plan of improvement. In stating this opposite theory of the case, I shall, as nearly as I can remember, repeat the words of Don Maximillian Sonnenstern, the accomplished engineer of Nicaragua.

"The sand-bar (Punta Arenas) which now separates the Greytown basin from the sea is a part of the delta of the Lower San Juan River, and is formed from material swept down this river in floods. In former times, the Lower San Juan received a much larger proportion of the waters of the parent stream, and was able to maintain a grand opening to the sea; but recently the main river has chosen to send its waters to the sea by the Colorado, and in this way the Lower San Juan has been deprived of the power of pushing its *débris* into the sea, and thus maintaining a ship-channel through *Punta Arenas*."

I think I have stated the two theories fairly, and it only remains to add a few considerations which have confirmed me in the view held by the committee of the academy:

1st. Standing upon the outer beach of Punta Arenas, I have been witness to the movement of the sand to the westward. The waves drive on *diagonally* (at an angle of 45°), carrying up the strand gravel, shells, &c., which, upon the recoil, are, for the most part, carried down again to the sea, but in a direction *normal* to the shore-line. In this way, by a zigzag movement, the sands, &c., travel slowly along the coast, and pile themselves up against the main shore to leeward. It is precisely the same movement that has formed Long Point at Provincetown and Sandy Hook at New York. The only difference is that at Provincetown or New York we have the mole in that earlier stage of its formation at which it acts as a breakwater and not a barrier.

In the interval between Captain West's survey of 1865 and that of Commander Lull's of 1872–'73, there accumulated upon the western shore, *to leeward of the inlets through which the river-waters had been discharged*, over twenty-five acres of dry sands, in addition to that found by Captain West. A single line of levels over these sands, made by Mr. Menocal and myself, gave 6½ feet summit elevation over the site of the ship-channel of fifteen years ago.

2d. The sands, &c., composing Punta Arenas are like many other beaches, as far as regards the size of the grains, &c., both on the ocean and basin sides.* In other words, the mole is built of *selected material*, sifted out by the long-continued action of the sea—the work, not of a few years, but of centuries perhaps. These selections have been made from a vast deposit of mud, of which they form an exceedingly small proportion.†

3d. The once grand entrance of Greytown could not have been maintained by the San Juan, even if it had been the only avenue of discharge from the main artery. One has only to divide the discharge (measured by any of the engineers) into the cross-sections of the ship-channel given upon the old charts, to discover how powerless the seaward flow must have been. From the best computation that I can make with the data at hand, I find that in 1832 the section of the entrance to Greytown was *seventy times* the area that we have now in the Lower San Juan at the head of the passes; *eighteen times* the section of the main river above the Colorado in dry seasons; and *seven times* the sec-

* The grains are smaller than those of Long Island, but correspond pretty well with those of Cape Fear.

† Cross-sections run by Captain Huer and Lieutenant Miller gave the usual forms of profile for traveling-beaches.

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tions of the main river in "top-gallant floods".* Even as late as 1853, the section at the entrance to Greytown Harbor was five times as great as that of the main river.

The work of restoration.—Since the principal element in the scheme of reconstruction is the amount of resistance to be offered to these causes of obstruction which we have discussed above, it may be important, by the comparison of the two last surveys, to measure, as well as we can, how much work injurious to our purpose the natural forces are doing.

In the interval between Mr. West's survey of 1865 and Captain Lull's of 1872, the narrow strip of beach westward of the meridian of the Greytown Catholic church has been continually modified in the contest between the waves of the sea and the outflows from the basin. The waves driving from the northeast before the trade-winds have sought to crowd the sands directly along the shore to the southwestward, while the pent-up waters of the basin have repeatedly burst through the beach and forced the sands seaward at the successive points of attack. The result of this contest has been that this strip of beach has moved to the northwestward in the course which we may presume to be that of the resultant of the forces at work. This movement has enlarged the basin superficially, but at the expense of its depth.†

Aside from the sediments of the river, there seem to have been accumulations due to the forcing-in of material from outside with the flood-current and the waves. The shoaling amounts to an average of 2½ feet by comparison of the same areas.

Assuming that the water-front of the town has remained unchanged for the distance of a nautical mile westward of the Catholic church, I have been able to bring the maps of 1865 and 1872 together pretty well; and I have drawn a north and south line (magnetic) through a point 1,250 feet west of the church to define (for convenience) the eastern limit of the basin. In the interval between these two surveys, there has been a decided advance of the bank of mud at the mouth of the Lower San Juan. The comparison of the maps gives this about 40 acres; but it would be difficult for any two surveyors to agree in the areas of these banks, because their limits are not defined. These are "drowned lands," with almost imperceptible slopes toward the basin at many points, so that one cannot say just where the nominal shore-line should be placed. There is, however, no doubt of there having been a considerable advance, *and yet the cubical water-contents of the basin have declined only 2 per cent.*

The change in the area of dry sand is likewise no criterion for judging of the increase of the mole which has cut off the basin from the sea. One might suppose, from the correspondence of areas between the Punta Arenas of Captain West and that of English charts twenty years earlier, that the advance of the point had been made with material robbed from older parts of the beach; the strip of land seeming to have undergone an attenuation as it crept forward. A comparison of soundings outside, however, quickly dissipates this impression, and shows that a great movement and accumulation of sand has been going on along the bottom as far seaward as the four-fathom curve at least, and that the fluctuations of the dry summit are unimportant phenomena physically.

If we compare the space which, upon Captain West's map, lies between the inside shore-line of Punta Arenas (continued on its general trend) and the five-fathom curve outside, with the same actual space upon Commander Lull's map, we find the increase of dry beach about fifty-two acres, which, at its average height, about 3 feet, would represent only about a quarter of a million of cubic yards; but, taking the submerged volumes, we discover that Punta Arenas has received deposits (on its seaward side) to the amount of five and a third millions of cubic yards, being an average of 730,000 cubic yards per annum.‡

As we might have expected, from the nature of the movement down the outside shore before the sea, the most rapid accumulations have taken place at the end of the beach, where, on reaching the mainland, the further progress of the material is arrested. Here, in a triangular space of one hundred and sixty-five acres, the dry land has increased from eleven acres in 1865, to thirty-seven and a half acres in 1872, and the water-volume diminished from three and a half millions, 1865, to one and a half millions, 1872. §

Our purpose in stating the accumulations in this triangular space separately is to give some measure of the rapidity with which the material is likely to advance toward the end of any jetty or groin which may be extended from the beach, with a view of arresting the progress of the sands which might tend to incumber an artificial opening through the beach. We shall refer to this matter again presently from another point of view, but must pause here to consider the relations of the river to the beach.

The material of Punta Arenas, like other beaches, is sand sifted by the sea. It is probably derived indirectly from the San Juan River, precisely as the sands which are encroaching upon the western pier of Port Säid are derived from the Nile; but we have no data for computing how long ago the river delivered to the ocean the enormous mass of mud from which these grains of sand have been so carefully selected. River-muds are usually over 90 per cent. sand, but mostly very fine sand as compared with that on outside beaches. In illustration, I will recall an incident connected with our physical survey of Mobile River and Bay made a dozen or more years ago. Along the shore of this bay, in Garrow's Bend, there is a little belt of white sand which I could not believe was the product of the dash

* Mr. Barnes, a resident at the "Forks," pointed out the height of what he called the "*top-gallant floods*," of which we measured the elevation.

† The two tracings from the original surveys of Captain West and Commander Lull (both executed under difficulties) are differently oriented, there being some difference probably in the compasses used; and their distances do not agree, so that, aside from the outward movement of the dry beach, there is a difference of areas, which is accidental, amounting to over seventy acres, Commander Lull's map being the larger.

‡ The whole area of the space is 742 acres. Want of numerous and coincident soundings makes this a rough computation. I make the total 5,379,110 cubic yards, and the interval of time seven and a third years.

§ From 3,678,400 to 1,557,802, as computed from data insufficient for nice statement.

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of the waves against the bluff, because the latter was composed of a very fine yellow clay. General Totten, however, to whom I gave specimens of both materials, succeeded, by treating the clay with acids, and by laborious washing, in detecting a few grains of the very same sand which lay at the foot of the bluff; but the ratio of these to the bulk of material from which they had been selected was too small to be determined. At the mouths of rivers which are rapidly extending their deltas, one does not find the sand sifted out in recent deposits; but at some ancient mouth, long since closed to the discharge of river-floods, he may find a belt of beach-sand, having a very foreign aspect, but really sifted from the river-muds in the long course of time.

The Lower San Juan has so extended its delta as to merge its mud, of late years, with the sands of Punta Arenas (or Isla Castilla, as the eastern portion of the beach is called), but the ground over which it advances is much of it shallow, so that a small volume of sediments makes considerable area. We have not succeeded in making any satisfactory computation of the amount of *débris* brought down by this river, but it does not, I think, exceed a hundred thousand cubic yards per annum as measured in the Greytown basin.

The plan already proposed by Commander Lull for restoring the harbor comprises three important works, viz, the dredging away of a portion of Punta Arenas and its aproning of shallow ground; the construction of a jetty to windward of the new opening, so as to shelter the approach from the sea and protect the channel from the wash of the waves; and the diversion of the waters now flowing through the Lower San Juan into the Colorado by obstructions at or near the forks. The object of the last-named work is to prevent sediments from incumbering the Greytown basin, etc.

This plan, as far as regards the main points stated above, is not inconsistent with the view I have adopted relative to the causes of injury heretofore and the obvious means of resisting them in the future, and I purpose to discuss this plan, not to present any fundamental objections, but to see how it answers criticisms from this different standpoint:

1st. A jetty designed to arrest the traveling sands of the coast most effectually should extend in a direction nearly normal to the shore, and yet have a tendency to turn the sea slightly shoreward, so as to prevent the sands from escaping by the *race* round the end of the pier. The jetty plotted upon the map sent to me answers these tests pretty well. A position has been chosen where a line at right angles to the general shore-line (which trends southwest in this neighborhood) is slightly inclined toward the direction of the sea, which, although created by the northeast trade-wind, is modified in the direction of its onset as it approaches the coast so as to strike at a less angle than it would if driven directly before the wind.

2d. The jetty intended to shelter the approach to the interior basin should serve as a breakwater to vessels obliged to come to anchor outside when unable to come in by reason of darkness or when waiting for a tow.

The jetty, as plotted, 3,000 feet long, will shelter nine ships under its lee, as the bottom now lies, and double this number if dredging is done within a reasonable distance of the beach and the entrance. These estimates are based upon the consideration that the wind is nearly constant, so that vessels may be expected to swing together over an octant of 500 feet radius, and that the least depth of water required will be 18 feet.

We are told at Greytown that vessels anchor at all seasons of the year on this coast, and escape injury, although they lie uncomfortably, even in ordinary weather, while the trade-winds prevail.

The sea of the Caribbean is very high, but it is very short from rear to front, so that a wave has no great volume, and under the shelter of a breakwater no considerable swell may be expected. Captain Selfridge informed me that he had found the water perfectly quiet in Porto Bello when the sea outside was running very high with the northeast trade-wind. This harbor is a good illustration, because it is scarcely two miles long, and opens divergently toward the sea. The exposure is, however, to the southward of west, so that the sea runs away from it. We shall have occasion to refer to this again when we come to speak of ports on the Pacific side of the Isthmus.

It may be found necessary to extend the jetty at Greytown; to add a *kant* running westward from its extremity; but this could only be decided upon after ascertaining how fast the sands are disposed to creep out on the windward side, and how they may be inclined to deposit themselves beyond or within the end of the structure.

We may venture, not without misgivings, because of the inadequacy of our information, to make an estimate of the time that may elapse before the sands would accumulate as dry beach out to the end of the proposed jetty. We have already seen how rapidly the accumulations have taken place against the west shore, and we know that we have to resist the movement of nearly three-quarters of a million of cubic yards per annum. It is an important question *how far the reaction of the jetty may extend to the eastward*, because upon this reaction depends the form which the bank will take. At Port Säid, which is situated on the flank of the delta of the Nile, much in the same way that Greytown is placed relative to the main delta of the San Juan, the accumulations have taken place in long triangular banks with bold fore shores. Instead of piling up directly against the jetty, the shore, for perhaps a mile, has moved outward, each deposit against the mole having reacted and formed another deposit farther back. In this way, the advance toward the end of the structure has been very slow. In a very general way, perhaps, we can detect a similar reaction along the shore since Punta Arenas completed its advance westward; at all events, the outward movements, although irregular from point to point, are not in any respect confined to the immediate vicinity of the obstruction (the main shore). On the contrary, they happen to be less there than farther eastward, although the volume of accumulation is greater. Rejecting the shore-line, however, as being the least important contour, because the most liable to accidental movement, we shall descend to the four- and- five-fathom curves and observe how they have advanced.

In the interval between the survey of Captain West and that of Commander Lull, seven and a quarter years, we find that the fore slope of the beach between the four- and five-fathom lines moved out, in the average, 100 feet per annum. At these depths it is hardly likely that the washing away of the beach in storms has had much effect; and

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of course, one of the first steps taken (should improvements be decided upon) will be to secure this beach, so that we need not take these accidents into account.

It is a curious fact that in the first 3,000 feet from the west shore (measured along the present beach) the increase of dry land was just as great as it was for the next 7,000 feet eastward (26½ acres), while the accumulation above and below the water's surface was two and a quarter millions of cubic yards in the first instance against three millions in the second.* So that while the dry land increased its area in the vicinity of the obstruction (the west shore) more than double as fast as at points beyond *its* influence, the accumulation in the neighberhood of the obstruction was only at about 67 per cent. higher rate. Now, supposing that the reaction of the obstruction continues along shore, we may finally conclude, from the foregoing argument, that a jetty built as proposed will cause an advance of the submerged contours at a rate not greater in the average than 167 feet per annum; and if the bank that is formed takes the successive shapes which repeated surveys gave at Port Sāid, this rate will be reduced from year to year, because the base of the triangle of deposit will extend farther and farther eastward. There may be expected a rapid filling up of the inner portion of the angle behind the jetty, especially where the water is now shallow.

As the filling proceeds, the contours will trend more nearly parallel with the crest-line of the wave, the reaction will extend farther along the shore, and deeper water will be reached. Here are three substantial reasons for expecting a reduction in the rate of advance of the back side of the jetty. From comparisons of our recent maps with the old British charts, it appears that the waves are not *directly* active along the space between the five- and six-fathom curves. Opposite the original opening we still find a five-fathom channel leading up a little way toward the beach, where no deposits have taken place. This channel has been narrowed down by encroaching banks, but there is still a considerable space left at the old depth.

The accumulation behind the jetty will probably take a steep fore shore, and in the time we have given above for this jetty to fulfill its office enough will be learned concerning the manner in which the sands are disposed to accumulate beyond the pier-head to enable the engineer perhaps to turn this very accumulation to account in securing greater shelter to the roadstead.

The Dutch have found on the coast of Holland, in using fascinage, that the traveling sand can be made to do service in giving permanence and strength to structures designed to resist the action of the waves. In building the proposed jetty, which I understand to be an initiatory step, it would be well to use fascinage near the shore, because of its tendency to gather the sands and holding them, and because heavier materials would be likely to sink. Cribs would be likely to be eaten by the worms, but blocks of artificial stone made from the lime of the country and the sand of the beach would be durable, if we may judge from the firmness of similar material used for wells and indigo-vats near Rivas.†

Obstructions of the Lower San Juan.—A comparison of the gaugings made by Childs, West, and Lull shows that the Lower San Juan is losing its capacity of discharge, and that we may expect, at no distant day, to find this stream relinquishing its office as an outlet from the main river, at least in the dry season. Commander Lull's project provides for hastening the decline of this stream, by placing obstructions in the shallow sections of the river near the *Forks*, so as to induce the main river to send all its *débris* to the sea through the Colorado. An inspection of the locality discouraged in my mind this bold provision. It seemed to me hardly likely that the operation would meet with success proportionate to the cost in time and labor, and might possibly be the cause of overflows across the peninsula between the two streams, which would bear suddenly into the Lower San Juan more silt than it receives, under present conditions, during several years.

We ran three short lines of levels over the river-banks, two of them on the peninsula, about half a mile below the forks, and one of them at a point on the left bank, where we had ascertained that high floods had been seen to reach on rare occasions. We found the peninsula banks 12 feet and the high flood-level 14.

We observed, in crossing the peninsula from the Colorado to the Lower San Juan, that the land was low and swampy midway, and Mr. Barnes (to whom I have before referred) stated that farther down toward the sea there were extensive interior lagoons. Of course, there is nothing peculiar in this case. It is the general rule in alluvial countries that the highest ground lies close along the river-side. Mr. Barnes informed us that the "*top-gallant floods*" only came over into the interior, and they occur only once in about four years. He said he had on one occasion gone from river to river in his boat about on the line that we had traversed.

It would be so very desirable to have the Lower San Juan turned off at this point that a careful experiment might be well worth trying. But failing in this, another plan of excluding the *débris* from the Greytown basin will naturally suggest itself, viz, the building of a dam from Punta Arenas to the Greytown shore, across the passes of the delta. Referring to the map, it will be observed that there is a communication between the river and the sea at Harbor Head, besides the Tauro outlet, which lies farther westward. The reduced discharge of the river ought to find these sufficient, or easily made so, without much backing up of the stream. In connection with the Greytown Harbor improvement the shore to the westward of the jetty and the beach behind it would require arming, as before stated, and communications between the basin and Harbor Head would probably have to be stopped altogether to prevent circulation. A

*2,249,342 and 3,129,798 cubic yards of filling, of which 2,120,598 and 3,004,794 represent water-displacements from Captain West's chart in territory still covered with water, is beyond the present shore-line.

I have no information concerning the jetty at Port Sāid since 1868, the date of my visit, when I procured tracings of surveys of the successive shore-lines. I discussed the Port Sāid Harbor in an article on the Suez Canal, which appeared in the North American Review for October, 1869.

†The shore sand on the west side of Lake Nicaragua resembles that of Greytown beach, especially in its magnetic quality and its general aspect, and we are told that this sand had been used for béton very successfully.

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dam, then, indirectly connecting the proposed jetty with the main shore, near the village of Greytown, would seem to commend itself as serving many uses.

RECAPITULATION.

Result of foregoing discussion.

1st. The supposed jetty is well located, whether regarded as a breakwater only or as a main groin for arresting the moving sands of the coast, and will perform the latter office for twenty years.

2d. This jetty should be built of fascinage as far as practicable, and of artificial blocks *pell-mell*, rather than heavier natural stone.

3d. As adjuncts to the jetty proposed, other works will be necessary to arm the beach against the attacks of the sea and give firmness to the abutment.

4th. Should an experiment show that there is no reasonable hope of turning the Lower San Juan into the Colorado by a more rapid process than nature seems to be attempting, a dam from the jetty to the Greytown shore is proposed as an alternative plan for excluding the river *débris* from the Greytown basin, and incidentally serving other purposes.

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APPENDIX E.

ARGUMENTS FOR AND AGAINST THE TEHUANTEPEC SHIP-RAILWAY PROJECT.

[Extracts from the Report of the Committee on Commerce, United States Senate, Forty-seventh Congress, first session, to whom was referred the bill to incorporate the Interoceanic Ship Railway Company.]

IN THE SENATE OF THE UNITED STATES.

MARCH 6, 1882.—Ordered to be printed.

Mr. VEST, from the Committee on Commerce, submitted the following report (to accompany bill S. 430):

The Committee on Commerce, to whom was referred the bill (S. No. 430) to incorporate the Interoceanic Ship-Railway Company, and for other purposes, have had the same under consideration, and beg leave to submit the following report:

The first question the committee considered was as to the practicability of constructing a railway for the purpose of transporting ships and their cargoes. The testimony before the committee conclusively demonstrates the fact that such a railway is entirely practicable, and that loaded vessels can be transported over the same with absolute safety and economy.

The committee does not consider it necessary to enter into the details of the proposition thus stated, but refers to the following testimony upon the subject, given by the most prominent and able engineers and naval architects in the world.

In the first place the committee would refer to the testimony of Sir Edward J. Reed, K. C. B., late chief constructor of the British navy, who, in passing through Washington, kindly appeared before the committee at its invitation and gave it the benefit of his views. The statement of Sir Edward Reed will be found printed in full in the testimony taken before the committee.

But the question of the practicability of a ship railway does not depend alone upon the testimony of one engineer, however distinguished. Mr. Eads submitted to the committee a number of letters and certificates from the most distinguished engineers and naval architects abroad and in this country. Attention is called to the following extracts from some of these certificates and letters.

Nathaniel Barnaby, C. B., present chief constructor of the British navy, in a letter dated London, October 8, 1881, says:

"I note, therefore, the question you wish to put to me, which is: 'Do I think the problem insoluble of constructing a car on which a fully loaded ship can be safely transported over such a railway as could be built through a tolerably level country?'

"In reply to this, I say not only that it is soluble, but that the solution is, in my opinion, fairly indicated in your plans, as laid before the committee on interoceanic canals and shown to me.

"Ships which would be strained by ordinary docking would be liable to be strained also when suspended on a car not specially designed for their crazy condition, but such ships would be still more strained in their ordinary sea passages."

Mr. William John, who was for some years the scientific adviser of the committee of Lloyd's Register of British Shipping, London, and who built the Inman steam liner the City of Rome, in a letter dated October 6, 1881, says:

"The practice of lifting a ship of large size clean out of the water has become an every-day occurrence. The further step of lifting her to a considerable height is not a great one, especially if you can start with her floating in a considerable depth of water. Beyond these the conveyance of her over a railway, provided the latter is moderately level and moderately straight, is a simple matter, which is certainly not outside the reach of civil engineers."

Mr. John Fowler, who was consulting engineer of the Egyptian Government, engineer in chief of the Metropolitan (underground) Railway of London, and who is a past president of the Institute of Engineers in England, says:

"You will be interested to know that about eight years ago, when acting as consulting engineer to the Egyptian Porte, I was instructed to prepare a project for the transport of steamers and other vessels from one level to the other at the first cataract of the Nile.

"After a very careful investigation of the alternative plans of canal and ship railway on the spot, I decided in favor of the railway, having satisfied myself that there was no mechanical difficulty in carrying ships of any size, without injury to themselves, on a properly designed car or cradle over a solidly constructed railway."

Mr. George Fosbury Lyster, a member of the Institute of Civil Engineers, in England, and engineer in chief of the Liverpool docks, in a letter dated November 2, 1881, says:

"In reply to your letter of the 16th ult., referring to the several interviews I have had with you during your recent visit to this country, on the interesting subject of your proposed ship railway across the Isthmus of Tehuantepec, as also to the papers which you were good enough to leave with me, further illustrating your opinions on the

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point, I have now been able to give the whole matter, as far as its engineering features are concerned, very careful consideration, and have concluded that if the permanent way, cradle arrangements, and general details are carried out in the ingenious and substantial manner you described, there will, in my judgment, be little or no difficulty in transporting properly constructed ships from sea to sea with entire convenience and safety."

Mr. E. Leader Williams, member of the Institute of Civil Engineers in England, in a letter dated September 5, 1881, says:

"I believe that your ship railway only requires carrying out into execution to prove most successful in every way."

The firm of Clark & Standfield, distinguished English civil engineers, one of the members of the firm (Mr. Edwin Clark) having been the chief assistant of Robert Stephenson in building the celebrated tubular bridge over the Menai Straits, and who introduced the hydraulic vertical-lift system, in a letter to Mr. Eads, dated London, September 6, 1881, says:

"Referring to our interview on the subject of the proposed ship-railway across the American isthmus, we now beg to say that our works are likely to be so much occupied during the next year that we should scarcely be in a position to execute any works out of England in connection with the proposed railway, but we should be very happy to prepare the drawings for the construction of the terminal works, for lifting the vessels at the Atlantic and Pacific ports.

"We understand it will be requisite to transport loaded vessels of the weight of 4,000 to 6,000 tons, more or less, on the railway, at the rate of about 6 miles per hour, on a gradient of one or two per cent., and that it will be required to raise the vessels on a railway car out of the water to a variable height, not exceeding 46 feet, and deposit them on the rails in a time not exceeding thirty minutes. These conditions may be fulfilled in two different ways, and we need not say that it is a plan in which Mr. Edwin Clark has entire confidence, and in which he will take the fullest interest in arranging the details. The hydraulic system would probably be the most rapid, but probably the more costly. At the Bombay hydraulic dock we have lifted weights up to 12,000 tons, with 72 presses, 14 inches diameter, and 36 feet stroke. The Victoria and Malta hydraulic docks have been many years in constant operation.

"At the canal lift at Fontinettes we employ presses with rams, 6 feet 7 inches in diameter, with a 50-foot stroke. Each of these presses will raise a dead weight of 1,000 tons through a height of about 50 feet in three minutes. The weight is a movable portion of the canal, about 132 feet long, containing the water and a barge floating in it. This work is now in course of construction for the French Government, and it is to be erected near St. Omer, in France, and we are now designing a set of four similar canal lifts for the Belgian Government, in which the weight raised will be somewhat larger. It is evident that a few presses such as these would more than accomplish the work required.

"Our ordinary depositing dock, similar to that at Sebastopol, which raises vessels of 6,000 tons, would also meet the requirements of the case very satisfactorily. We are now constructing a second of these docks, of 10,000 tons, for the Russian Government at Vladivostok, and a third, of 3,000 tons, for the Barrow and Railway Company, at Barrow-in-Furness, to be afterwards increased to 5,000 tons. We have designed one of these docks for the Italian Government, to raise iron-clads of 15,000 tons weight with a lift of 30 feet. There would be no difficulty in modifying the proportions so as to render it suitable for a lift of 46 feet, and this form of dock raises the vessels out of the water and deposits them on a gridiron stage in a most convenient manner for railway transport.

"It will probably depend to a great extent on their relative cost as to which of these systems may be adopted, and we shall be prepared at any time to go into the necessary calculations, and render every assistance in our power towards the accomplishment of the great work in which you are engaged.

"We apprehend no difficulty in perfecting the necessary details of the plans, so as to insure the safe transportation of the largest loaded ships on the railway cars with absolute safety."

The firm of Emmerson, Murgotroyd & Co., who were the constructors of the hydraulic docks at Malta and Bombay, say, in a letter dated October, 1881:

"JAMES B. EADS, Esq., C. E.:

"MY DEAR SIR: When you are ready to commence the construction of your ship-railway, we shall be pleased to undertake the building and completion of the necessary works for placing the ship, with her cargo, on the railway track, ready for attaching the locomotives to her, and after transport across the isthmus to lower her safely again until she is afloat. A lifting apparatus will be required at each side of the Isthmus which will lift or lower ships as required. This portion of the work we are fully prepared to execute with the greatest promptness, on the same terms on which we built the hydraulic docks at Bombay and Malta, and the Anderton Canal lift in Cheshire.

"We have no hesitation in guaranteeing the lifting of a fully loaded ship or steamer of 8,000 or 10,000 tons weight on a railway car from the sea or harbor level to that of your permanent way in thirty minutes, with absolute safety to the ship and the works, where the lift is not over 50 feet vertically. We will undertake to construct all the plans and works necessary to do this at each end of your line, and complete everything ready for attaching the locomotive to the car on which the ship is to be lifted and transported; this car, or any number of them, we will furnish also.

"The locomotives and railway construction are not in our line; but if it were a matter of importance to cover, in addition, the construction of the locomotives, turn-tables, &c., and 10 miles of railway, as proposed by you to the United States, we have no doubt we could unite with us some other responsible parties engaged in that kind of works, to execute them and guarantee the safe transportation of the loaded ships of the weight mentioned, over the railway."

Mr. William Pearce, sole proprietor of John Elder & Company's works, Govan, Glasgow, and who built the Arizona, the Elbe, the Alaska, and others of the largest and finest steamers afloat, in a letter dated August 26, 1881, says:

"I am of opinion, from what I know of the working of iron floating docks that I have designed and built, that iron steamers of 4,000 to 5,000 tons displacement may be docked, loaded, without any injury whatever.

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"It is also my opinion that a ship-railway for vessels of this size may be constructed and worked successfully, provided the land is solid and the line moderately level."

Capt. Edward Hartt, United States naval constructor, says, in a letter dated Orange, N. J., January 22, 1881:

"With a substantial road-bed for your railway, on the easy grades across Tehuantepec, which, I understand, do not exceed one or two feet in the hundred, there can be no mechanical difficulty in the way of transporting loaded ships by railroad with entire safety to the vessel, whether they be built of wood or iron."

Mr. H. L. Fernald, another constructor in the United States Navy, says:

"Having carefully examined the plans and papers pertaining to your proposed ship-railway across the Isthmus of Tehuantepec, I do not hesitate to say that, in my judgment, there will be no difficulty whatever in transporting, in the manner you propose, any properly-built vessel with absolute safety."

General Q. A. Gillmore, of the United States Engineers, says:

"In my judgment the construction of a ship-railway across the Mexican Isthmus, in general accordance with your plan, is not only feasible as an engineering problem, but the successful maintenance and operation of such a road is entirely practicable as a business enterprise."

Maj. Charles R. Suter, of the United States Engineers, says:

"The project has great and obvious advantages to recommend it; and from an engineering point of view, it is, in my opinion, perfectly practicable."

Prof. E. A. Fuertes, dean of the department of civil engineering in Cornell University, and chief engineer in the survey made by Commodore Shufeldt, of the Isthmus of Tehuantepec, and who was for eleven months upon the Isthmus, says:

"When your ship-railway project appeared, and was ridiculed by inconsiderate engineers, I made computations which proved conclusively to my mind that the Great Eastern could be carried safely overland upon rails with less strain to her timbers than in any of her sea voyages."

Again, in speaking of the grades which would be encountered upon the Isthmus of Tehuantepec, Professor Fuertes says:

"I can assure you, upon knowledge of every inch of the ground, that you will find no difficulty about curves, grades, or bridges. The ascent of the Atlantic slope will offer no more difficulties than the Hudson River Railroad; and on the Pacific side, either one of the three passes in the neighborhood of Tarifa or Chivela will allow of no steeper grade than 25 to 35 feet per mile to bring you down to the Pacific plains. The ground offers you 50 miles to get down in, and as much more as you may wish by following the hillside. All the bridges required will be of comparatively short spans. You will find very little anxious work on either terminal harbor, very little tentative work being required, and permanence without ulterior complications will reward almost any kind of attack. The drainage of the works, building materials (including excellent cement-yielding, dolomitic limestone, between San Miguel and Tarifa), abundant native labor, a remarkably healthy climate, etc., will be all you may desire."

Don Francisco de Garay, whom the French Government made a member of the Legion of Honor in recognition of his abilities as a civil engineer, and who was detailed by the Mexican Government (he being the engineer of the valley of Mexico) to make a survey of the Isthmus after the concession was granted to Mr. Eads, in a report to Mr. Eads, dated Mexico, September 22, 1881, says:

"Now with regard to grades: I have no grade on my line above 2 per cent., and for no greater distance than 2¼ miles. The ascent to the summit, as well as the descent, are constant, but divided in different short sections.

"To resume what we have said, we see:

"1st. That the line traced and located by our commission for the present is only a study, that may be improved and perhaps even abandoned for a better line, if, in subsequent surveys, more favorable ground is found.

"2d. That such, as it has been traced and located, the line from the Pacific to the Chichihua River, has only one break in a distance of 50 miles.

"3d. That in all the line there is no grade greater than 2 per cent., and in no greater distance than 2¼ miles.

"4th. That the greatest cutting is 312 feet in maximum depth, and 2,500 feet in length.

"5th. And finally, that the results obtained have demonstrated the entire practicability of the ship-railway."

General G. T. Beauregard, formerly of the United States Engineer Corps, says:

"I take pleasure in communicating to you, in as few words as possible, my views relative to the practicability and economy of a ship-railway across the Isthmus of Tehuantepec. I feel no hesitancy in saying that I see no difficulty in constructing a railway strong enough to carry out the object referred to. It is only a question of the strength of the cradle to hold the ship, and the division of weight on a sufficient number of rails and wheels, which can certainly be accomplished by any engineer of ability and ingenuity.

"As to the danger a loaded ship would incur in being transported on a smooth and well-built railway, it is all imaginary, for it would be well braced and cushioned in a strong car or platform, supported by spiral steel springs on a very large number of wheels, which, being separate from each other, could be easily replaced if broken during the trip. Moreover, the breaking of one or a few of them out of so many would not endanger the rest.

"With regard to the economy of such a ship-railway, I would remark that the tonnage carried over it being moved entirely by machinery, and the ratio of paying cargo to dead weight being much greater than on ordinary railroads, the cost of operating such a railway must be much less. The cost of maintenance should be also less in proportion, for the road would be substantially built and short in comparison to the amount of tonnage carried over it. Moreover, the machinery used would be simple and substantially made. It is, therefore, safe to assume that the current expenses and those of maintenance would not exceed 50 per cent. of the gross receipts, which would be more

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profitable than from a canal costing probably two or three times more than a ship-railway, and requiring three or four times longer to build, thereby increasing greatly the amount of interest alone on the actual cost of the canal.

"A ship-railway has other important advantages over a canal, such as the facility with which the number of trucks could be increased to accommodate the demands of commerce; the rapidity of transit, and the greater number of vessels per day that could be transported than through a canal; the practicability of building a railway where a canal would be impossible; the ability of estimating correctly for the first, while the latter, if partially built under the water, or liable to be submerged or interrupted by water, would be very difficult, if not impossible, to be estimated for as to cost and time of completion."

Mr. H. D. Whitcomb, civil engineer in charge of the works for improvement of the James River, says:

"The idea is worthy of the age, and to make it a success you have simply to improve and expand the details of the old marine railway and make it more perfect. I have the greatest confidence in your ability in this particular, and hope you will have the opportunity to demonstrate it."

Mr. William F. Buckley, president of the New York Balanced Dock Company, in a letter to Mr. Eads, dated February 14, 1881, gives the following list of vessels taken out on his dock with cargoes in them: Ship Great Victoria, 2,386 tons; ship Triumphant, 2,046 tons; ship America, 2,054 tons; ship Hagerstown, 1,903 tons; ship S. C. Blanchard, 1,903 tons; steamer Colorado, 2,765 tons; steamer Rio Grande, 2,565 tons; steamer Thingvalla, 2,436 tons; steamer Monarch, 2,366 tons; steamer Lepanto, 2,310 tons; steamer State of Nevada, 2,488 tons; and says:

"We do not refuse any class of ships or steamers, even with their coals and cargoes on board, whose length does not exceed the length of the dock. In every case in which we have taken up steamers with cargo in, it has been done without the least strain or injury to the vessel. As the rule is to make a charge for raising cargo in the vessel, they usually come without cargo."

The above are some of the witnesses as to the entire practicability of a ship-railway. There are many others of equal distinction in their profession who have expressed the same views, but the committee does not consider that it is necessary to quote further. The testimony upon this subject is so overwhelming and conclusive in its character that the committee has no hesitation in reporting that the construction of a ship-railway and its successful operation are entirely practicable.

But even if there were doubt as to the practicability of a ship-railway, the Government of the United States could with perfect safety to itself pass the bill desired by Mr. Eads, because under the provisions of that bill the Government guarantee cannot attach or have any force or effect until the practicability of the project shall have been fully and satisfactorily demonstrated.

The next question arising is as to the best route for a transit-way for vessels across the Isthmus. During the third session of the Forty-sixth Congress a special committee of the House of Representatives charged with the duty of considering all questions relating to isthmian transit, after the most full and exhaustive investigation, reported in favor of Mr. Eads's ship-railway project, and selected Tehuantepec as by all means the most preferable route for the transit-way. In this report the committee say:

"Mr. Eads has selected the Isthmus of Tehuantepec, and your committee unhesitatingly finds and reports that, of all the routes across the Isthmus, Tehuantepec is essentially the American route. A glance at the map will at once demonstrate the correctness of this assertion. If a vessel leaving the mouth of the Mississippi River, bound for California or the Orient, cross the Isthmus at Tehuantepec, her voyage will be 1,250 miles shorter in distance than if she crossed at Nicaragua, and 2,200 miles shorter than if she crossed at Panama. If a vessel leaving New York, bound for the same destination, cross the Isthmus of Tehuantepec, her voyage will be 750 miles shorter than if she went by Nicaragua, and 1,250 miles shorter than if she went by Panama. Inasmuch as this large saving of distance chiefly affects only the commerce of this country and that of Mexico, and not the commerce of Europe, it must be at once apparent that the location of a transit-way at Tehuantepec is of vital importance to the commercial interests of the United States.

"The saving of distance is synonymous with cheap transportation. Both at Panama and Nicaragua, at various periods throughout the year, calms prevail to an extent which would greatly decrease the value of either of the routes for sailing vessels. Such, however, is not the case at Tehuantepec, as favorable winds always prevail there, thus affording a guarantee of no serious detention to sailing vessels seeking a passage by that route."

The committee has considered the testimony taken before the House committee, and fully indorse the statement that Tehuantepec is the American route, and that the transit-way should by all means be located there in preference to any other point upon the Isthmus.

STATEMENTS BEFORE A SUB-COMMITTEE OF THE COMMITTEE ON COMMERCE, UNITED STATES SENATE, RELATING TO THE BILL (S. No. 430) TO INCORPORATE THE INTEROCEANIC SHIP-RAILWAY COMPANY, AND FOR OTHER PURPOSES.

TUESDAY, *January* 24, 1882.

Present, the sub-committee, consisting of Senators Vest (chairman), Conger, and Miller, of New York; also, Mr. James B. Eads and Hon. A. G. Cochran.

STATEMENT OF MR. EADS.

Mr. EADS. I will read, for the information of the committee, a letter from the distinguished civil engineers, Clark & Standfield:

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"6, WESTMINSTER CHAMBERS,
"*London, September* 6, 1881.

"Mr. J. B. EADS, C. E.:

"DEAR SIR: Referring to our interview on the subject of the proposed ship-railway across the American Isthmus, we now beg to say that our works are likely to be so much occupied during the next year that we should scarcely be in a position to execute any works out of England in connection with the proposed railway, but we should be very happy to prepare the drawings for the construction of the terminal works for lifting the vessels at the Atlantic and Pacific ports.

"We understand it will be requisite to transport loaded vessels of the weight of 4,000 to 6,000 tons, more or less, on the railway at the rate of about 6 miles per hour, on a gradient of one or two per cent., and that it will be required to raise the vessels on a railway car out of the water to a variable height not exceeding 46 feet, and deposit them on the rails in a time not exceeding thirty minutes. These conditions may be fulfilled in two different ways, and we need not say that it is a plan in which Mr. Edwin Clark has entire confidence, and in which he will take the fullest interest in arranging the details."

I will state that Edwin Clark was the chief assistant of Robert Stephenson in the building of the celebrated tubular bridge over the Menai Straits, and is the engineer who introduced the hydraulic vertical-lift system.

"The hydraulic system would probably be the most rapid, but probably the more costly. At the Bombay Hydraulic Dock we have lifted weights up to 12,000 tons, with seventy-two presses, 14 inches diameter and 36 feet stroke. The Victoria and Malta Hydraulic Docks have been many years in constant operation.

"At the canal lift at Fontinettes we employ presses with rams, 6 feet 7 inches in diameter, with a 50 foot stroke."

I will state here that that is on the principle of the Anderton lift, where a single ram is used in the center of the section of the canal, some 130 feet long, in which two canal-boats are placed, the canal being 50 feet above the river Weaver. I went to see this work myself. It has been in operation seven years. There are two of these presses. When one is down, the other is up. I saw two canal-boats lifted in one of these basins from the river Weaver and put in connection with the canal in three minutes. The Government of France sent a commission to examine it, and were so much pleased with it that they have ordered one for this Fontinettes locality, of four times that power, to lift a thousand tons; and the Belgian Government also sent a commission, and they have ordered four of them for four different places on their canals, and they are to lift some 1,200 tons each.

"Each of these presses will raise a dead weight of 1,000 tons through a height of about 50 feet, in three minutes. The weight lifted is a movable portion of the canal, about 132 feet long, containing the water and a barge floating in it. This work is now in course of construction for the French Government, and it is to be erected near St. Omer, in France, and we are now designing a set of four similar canal-lifts for the Belgian Government, in which the weight raised will be somewhat larger. It is evident that a few presses, such as these, would more than accomplish the work required.

"Our ordinary depositing dock, similar to that at Sebastopol, which raises vessels of 6,000 tons, would also meet the requirements of the case very satisfactorily. We are now constructing a second of these docks, of 10,000 tons, for the Russian Government, at Vladivostok, and a third, of 3,000 tons, for the Barrow and Railway Company, at Barrow-in-Furness, to be afterwards increased to 5,000 tons. We have designed one of these docks for the Italian Government to raise iron-clads of 15,000 tons' weight with a lift of 30 feet. There would be no difficulty in modifying the proportions so as to render it suitable for a lift of 46 feet, and this form of dock raises the vessels out of the water and deposits them on a gridiron stage in a most convenient manner for railway transport.

"It will probably depend to a great extent on their relative cost as to which of these systems may be adopted, and we shall be prepared at any time to go into the necessary calculations, and render every assistance in our power towards the accomplishment of the great work in which you are engaged.

"We apprehend no difficulty in perfecting the necessary details of the plans so as to insure the safe transportation of the largest loaded ships on the railway cars with absolute safety.

"We remain, dear sir, yours, faithfully,

"CLARK & STANDFIELD."

The constructing engineers who built the hydraulic docks at Malta, the Anderton lift, and those great docks at Bombay have addressed me this letter:

"HEATON FOUNDRY, STOCKPORT, *October* 1, 1881.

"JAMES B. EADS, Esq., C. E.:

"MY DEAR SIR: When you are ready to commence the construction of your ship-railway we shall be pleased to undertake the building and completion of the necessary works for placing the ship, with her cargo, on the railway track, ready for attaching the locomotives to her, and after transport across the Isthmus to lower her safely again until she is afloat. A lifting apparatus will be required at each side of the Isthmus, which will lift or lower ships as required. This portion of the work we are fully prepared to execute with the greatest promptness, on the same terms on which we built the hydraulic docks at Bombay and Malta, and the Anderton Canal lift in Cheshire.

"We have no hesitation in guaranteeing the lifting of a fully loaded ship or steamer of 8,000 or 10,000 tons' weight on a railway car from the sea or harbor level to that of your permanent way in thirty minutes, with absolute

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safety to the ship and the works where the lift is not over 50 feet vertically. We will undertake to construct all the plans and works necessary to do this at each end of your line, and complete everything ready for attaching the locomotive to the car on which the ship is to be lifted and transported; this car, or any number of them, we will furnish also.

"The locomotives and railway construction are not in our line; but if it were a matter of importance to cover, in addition, the construction of the locomotives, turntables, &c., and 10 miles of the railway, as proposed by you to the United States, we have no doubt we could unite with us some other responsible parties engaged in that kind of works, to execute them and guarantee the safe transportation of the loaded ships, of the weight mentioned, over the railway.

"Very truly, yours,

"EMMERSON, MURGATROYD & CO."

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JANUARY 31, 1882.

Present, the members of the sub-committee, and of the Committee on Commerce, and numerous other Senators; also, Sir Edward J. Reed, Mr. James B. Eads, Hon. A. G. Cochran, and others.

The CHAIRMAN (Senator Vest). Gentlemen, I have the pleasure of introducing Sir Edward J. Reed, a distinguished English engineer, who is here for the purpose of addressing us in regard to the proposed interoceanic ship-railway. Sir Edward, we will be glad to hear you with reference to the enterprise.

STATEMENT OF SIR EDWARD J. REED.

Sir EDWARD J. REED. I must apologize to the committee for coming before it in a very unprepared condition, for I have had no time in Washington to attend to this matter. Under these circumstances I should not have presumed to have come at all if I had not made a very full study of this question previously; and the committee will allow me probably to trust to my memory and general knowledge of the subject.

I would say, in the first place, that I was induced to make a very full study of this subject by the receipt of a letter from a distinguished naval officer of this country, Admiral Ammen, who had heard that I had expressed some favor of the system of a ship-railway, and asked my opinion. I thought it due to him and to any persons who might do me the honor of reading anything I might say, and to this country, whose enterprise it seems likely to become, to study the matter fully and give my views as impartially as I could upon it.

When the question was first proposed one could not help feeling a little shocked at the suggestion, because every man of my age in my profession has been acquainted with ships that are very weakly constructed, and that have been built for a very different purpose than that of being lifted out of the water, with their cargoes on board, and taken over railroads. I felt sure that whatever hesitation professional men, like myself, might feel, the outside world would feel a great deal more; because it is our duty, of course, as professional men, to study with greater closeness the nature of the strains to which ships are subjected, and the forms of weakness which they develop at sea; and we get to know, naturally, what their actual conditions are; and their actual conditions, although sometimes worse, are usually very much better than any amateur would suppose; I mean better as regards their relations to the strains which they undergo in dock or when dry.

I ask you to bear in mind that we have to discuss this proposal under very different conditions from those which prevailed half a century ago. In the case of war vessels, with which I am pretty familiar, it is a fact that the French war vessels, of the greatest repute in war, at the end of the last and the beginning of the present century, and which were of course constructed of timber, were of so weak a construction that they gave up building them upon slips and launching them as ships are usually launched, because they underwent in the process of launching such enormous strains and distortions, and disturbance of all parts of their structure that they were almost ruined in the very act of launching. So the French took to building them in dry-docks, where they were carefully supported at all points until they got them floated, and then it was presumed that they would have the uniform support of the water over the whole surface of the bottom. It was found, however, that these ships were very badly strained at sea, and the fact forced itself upon the attention of scientific naval architects that a ship which was not strong enough to stand the strain of launching effectually, was certainly not strong enough for sea service. That is a lesson which has been taught all through the period of wooden-ship building, alike in this country, in my own, in France, and in other countries.

The fact is that wooden ships were built systematically weak, and they were always developing that weakness at sea. They developed it mainly in two ways: first, in longitudinal straining, tendencies to break this way or that way [indicating], upward or downward at the ends, and by transverse bending, tending to changing the angle which the side of the ship makes with the deck. Perhaps I may use a very familiar illustration of that point. Suppose that [indicating] to be the rough representation of a ship section. When the ship is working at sea, the tendency is for it to change its angle in that manner [indicating], and then she rolls over in the other direction, and changes it in that way [indicating]. The chief question in the strength of a ship is how to prevent that change of angle between the deck and the side. Hence, in this and other countries it was a great business in the days of wooden-ship building to get strong angular pieces of timber to serve as knees for ships, which would lie along below the beam, and down the side. The proofs of straining in the ships were always in the connection of those knees. The bower-bolt fastenings

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of the knee were always breaking and failing, and the working of the ship generally mastered the strength. From the same kind of straining they used to open the seams of the deck and let the sea through and create a great leakage.

I mention this only for the purpose of showing that it is incidental to a state of things which has largely passed away, and which will very soon have completely disappeared, because, although in this country and in Norway and some other countries there is a good deal of wooden-ship building, still I have no hesitation in saying that the wooden ships of to-day are vastly stronger everywhere than they were half a century ago, and that they are now, as a rule, perfectly capable of being docked in dry-dock, with their cargoes on board. Of course, if they can be docked in a dry-dock (a graving-dock, a sunk-dock) they could be docked upon an iron lifting or hydraulic dock.

Although there are risks in the docking of these ships with cargoes on board, those risks result entirely from the negligent handling of vessels, and have been almost wholly of one description. In this day of keen competition you are aware that the loading and unloading of ships is a matter that is pressed with the utmost rapidity, and one of the great elements of economy in ship working is in getting the cargo in and out in the shortest possible time. The cargoes of to-day are very various, and the danger of injury to a ship in dock, whether she be iron or wooden, now consists in having most of the weight, such as piles of steel rails, for example, or blocks of heavy machinery, localized on one part of the ship's bottom, while the neighboring parts perhaps have nothing in them at all, or very light cargo, and then the danger is that when you dock the ship by any means, that excessive weight at one spot may produce local injury. That is a state of things which does exist, however you dock the ship. I have known repeatedly iron ships and valuable ships to be docked so carelessly that they have been left until they have been completely dry without any virtual support at all under the bottom, and I have known the keels to cut down into the solid wooden blocks below them, and considerable mischief to be done by this negligence in docking.

I shall take it for granted, that in establishing such a system as that of a ship-railway, intended to take all descriptions of vessels across the Isthmus of Tehuantepec or any other place whatever, the very primary duty of the engineer will be to supply ample and sufficient means for giving local support to the vessel's bottom wherever that support is necessary. I should think in these days, for my part, the method of dealing with that would be by having hydraulic blocks or rams which could be brought up under the ship at any point that you desired to have them, and may be worked with the utmost rapidity. I suppose every gentleman present knows more or less of the marvelous manner in which all sorts of operations are now conducted by hydraulic power, which is led about to any position where it is desired, and controlled with the utmost exactness.

Therefore I should like to say at first, that as a naval constructor I have no fear whatever of a ship undergoing any strain in the process of lifting out of the water (as would be necessary in the case of a ship-railway) that she is not liable to at present in ordinary docking. I would say further that I am quite sure that the processes of ordinary docking, as carried on in a vast number of private establishments, are very negligent and insufficient in comparison with those which would be adopted in the case of the hydraulic lifts connected with the proposed ship-railway. We are not without experience in this matter. In the first place, there has been a system of lifting ships by hydraulic lifts at work on the Thames for many years. The object there was to lift a ship upon a ponton which would be of sufficient buoyancy to float her, and when she is lifted and floating upon the ponton, the ponton with the ship on it is drawn away to another part of the docks, and repairing is there carried on; and if the ship is an iron vessel she has her bottom cleaned and coated; and then if there is another ship to be docked it goes on upon another ponton, and is floated and taken away, and so on. That system has worked for many years without any failure whatever. No sort of injury to any ship has occurred; but I am bound to say that, as a rule, those ships have been lifted without cargo on the Victoria docks on that system.

But it became necessary to provide dock accommodation at certain foreign stations belonging to our country. For example, there was a dock wanted for Bombay. The Bombay Government had some vessels stationed there, and it was desirable for the Government to have the means of docking them; and the system they adopted was precisely this system of hydraulic lift, and a very large and magnificent hydraulic dock was constructed at Bombay. I mention this more particularly because it was constructed for the purpose of docking armor-clads. Every gentleman here knows doubtless that in an armor-clad ship the largest part of its weight is permanently in her or around her. The movable stores of an armor-clad ship are very small in comparison with the total weight, while in the case of a merchant ship the movable weights are large in comparison with the permanent weight of the ship. Therefore, to dock an armor-clad ship is really to dock a ship with the principal part of her cargo on board and under very unfavorable conditions, because the cargo of an iron-clad may be said to consist of her armor chiefly, and that is all situated upon the extreme outside of her, and acts with great leverage as regards the keel, whereas an ordinary cargo is laid over the bottom of the ship and is more or less equally distributed. This dock at Bombay has been in operation and has docked Her Majesty's ships several times, and some others, and there has been no sort of accident or complaint of any kind. On the contrary, everybody has been surprised to find that in no case has an accident occurred, whereas accidents with ordinary docks are not uncommon.

But a more characteristic illustration is to be found in the case of Malta, where a private company erected one of these hydraulic lifts with pontons like those I have spoken of, and it did so for the purpose of meeting a great necessity. There was no dock at Malta for private ships, and none was wanted much until the Suez Canal was opened. Then there was a great trade with India established through it, and the necessity of a dock was very much felt, because ships were having accidents and required dock accommodation between India and England.

Captain Eads has kindly put before me a photograph here, and it is a very instructive one, showing how ships are dealt with upon the dock.

This dock was first used as much as possible for vessels in a light condition, but obviously ships making their trade to India met with accidents when they were loaded, and some of those accidents, which were pretty frequent,

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made it necessary for them to hasten to this Malta dock as soon as possible, and it often happened that they could not discharge cargo before going on the dock; they were glad to get there as soon as possible to save them.

I have here a letter from the secretary of this Hydraulic Dock Company, giving a list of some of the vessels which have been docked with cargo on board. I will only pick out two or three of these. There is a vessel called the Volmer, of 1,531 gross tons, which went in with a cargo of 1,200 tons weight. A ship of 2,134 tons, gross tonnage, went on the dock with 1,700 tons of cargo on board. A ship of 1,555 gross tons went into dock with 1,500 tons of cargo, and others of like proportion of cargo to the size of the ship.

I would call attention to the fact that, although ship-owners at first were afraid of docking ships in that way with cargoes on board, they have discovered, by the experience of years, that no sort of injury does result therefrom. The ships that are in the Indian trade now voluntarily employ the docks and go upon them with their cargoes on board for the purpose of getting their bottoms cleaned and coated on the voyage instead of having to lie in a more expensive dock in London for the purpose.

That leads me to remark incidentally, if I should not be tedious, that there is a very great merit and commercial advantage in the system of raising ships upon iron docks, and it arises from the cause that, whereas you may dock a ship in a sunk graving-dock to paint her bottom, you must do one of two things: you must either put on a composition that dries very rapidly, and which therefore is not so good as a composition mixed only for the purpose of preventing fouling, or you must keep the ship a long time in the dock; because clearly if you put a ship in a hole it is in a bad position for drying, as it is for doing many other things; but when you bring her up into the air above everything else, as these ships are lifted, she is in the most favorable position, and it is found that a few hours suffice for the work of three or four days in an ordinary dock.

I would not like to dwell longer upon what I believe is the perfect practicability of docking wooden or iron ships with cargoes if they are docked with care. Now here is another question: Why put the ships upon a railway at all? Ships are made to float and steam in water. Why not keep them there and pass them through canals? In the first place, I think a canal is an excessively costly mode of passing a ship from one sea to another. It is a mode involving the trouble which always attends under-water operations, and that trouble is very great. The use of canals, as has been shown at Suez, is at times precarious. I have not had occasion to send merchant ships through the Suez Canal, but I had occasion to pass three men-of-war through it that I built for the Government of Japan, and which they asked me to deliver to them in Japan. Of course I had to send them out, and one of the three came to very great trouble indeed in that canal. She was a twin-screw vessel, and in the canal she was crowded and had her propeller knocked all to pieces and bent her screw shaft, and incurred a vast amount of expense and trouble. It is not at all an uncommon thing for the Suez Canal to be completely blocked by large ships grounding. It is a more common thing for ships to lie a considerable time while the channel is being cleared. Moreover, in the Suez Canal I have watched what no one could fail to see, indeed, in passing through it, and that is, where you have not masonry you have a continual washing-down of the sides of the canal; it goes on before your eyes quite plainly, and you have a continual permanent expense. But the Suez Canal is very favorably situated as compared with canals across the Isthmus that separates North and South America. I think there is another very grave objection. It is one that presses very much indeed upon my mind at home, as I think it may produce very strange results in the event of war. That is, the perfect facility with which any individual man can go and destroy a canal and stop the whole process. With a few pounds of dynamite flung by an Arab on the banks of the Suez Canal it would effectually dispose of that until you could clear it, or a man on board ship can go and sink a vessel in war time. Those devices could be resorted to with the utmost readiness, as you, of course, see, and the repair of the canal, being an under-water affair, is by no means easy. Were it a mere case of dredging, it would be easy to deal with, but where you are to have a series of inland locks of masonry, the destruction of them by dynamite would be an effectual destruction of the canal probably for the whole period of a war.

A ship-railway lies entirely under your own hands. If it be blown up by dynamite in one place nothing is easier than to lay it down again. It is all within the compass of your own operations, and it only wants the same materials as made it to enable you to repair it promptly.

I would like to mention what I think would be the view which I should take of this question if I were an American citizen. It is this: Even if there were doubts about the perfect security with which you could take some of your not very strong wood-built vessels across the Isthmus, I should say that the time had come when it would be worth the while of this country to take command of its own transit by such a route as this, or, rather, to give encouragement to it for the purpose of developing in America that which America ought to possess, namely, the means of conducting the transport of its own produce from one port to another. The grain trade of California and other neighboring States can be carried on daily much more cheaply by sea than by railroad across a vast continent like this, and you have nothing in the way but this 150 miles of isthmus.

I should say, as an American, if our ships are not adapted for this purpose at present, let them be made so, because the great problem you have to deal with is to transport this easily carried produce of grain; and I would say, fling away for a moment the idea of a ship and make a floating grain car which you can take over a railroad; regard it simply as a big car for carrying grain, make it as strong as you like for your railway purposes, make it of whatever shape you like for railway purposes, and when you have quite satisfied yourself that you can carry your own grain in your own cars across the Isthmus, then I will undertake to make that go as a ship to California on the one side or to New York on the other; because, in point of fact, the introduction of iron and steel has enabled you to steam at sea almost anything, if you give proper attention to certain things that have to be done which you could quite well do with a big railway car. I will undertake to say that an iron car fitted in the best way for taking grain and as big as a ship could be constructed and taken over the Isthmus of Tehuantepec and taken from there to the ports of discharge

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or of loading with the greatest possible efficiency, and it would have this effect, that you would commence a new industry here. The iron and coal of this country present the most favorable possible opportunities of developing an iron ship-building business. I believe myself that if there were no other reasons at all, and if you had not a single ship that was fit to pass over this railroad, it would be well to take the problem in its breadth and regard it as an enterprise well worth this country doing, and as building up a great industry.

I will not venture to say a word, of course, about the arrangements of this country with regard to tariffs and bounties and matters of that kind; but it does seem to me a most legitimate mode of encouraging a national enterprise is to deal with it as I understand Captain Eads under his concession with the Government of Mexico proposes to deal with it, which is to ask for a guarantee under certain conditions, and then to give to the country which furnishes the guarantee or the assistance in any form the right of one-half rates over the Isthmus for its shipping.

It would be very improper for me to press the adoption of this system upon gentlemen like you, because, to tell the truth, I am not anxious that it should be adopted in the form in which Captain Eads puts it. Looking to the enormous shipping interest which we have (we are 60 per cent. now in England of the carrying power of the world) I am quite satisfied that this enterprise can be dealt with by British ship-owners and capitalists, and I am quite sure also that when dealt with in the present day, and with interests of the kind we now have at home, they would obtain the protection of the Government for their enterprise. The premium of having half rates for the whole British shipping passing over that Isthmus would be so great a temptation that I would like myself to get Captain Eads to come over and ask us to take this thing up. But, however, as an American enterprise, I think it has great merit, and cannot fail, if constructed under the auspices of the United States Government, to greatly benefit your commerce.

But it may be said that the raising of a ship and floating it in the way that I have indicated is a very different thing from taking it across the Isthmus by railroad. I have had it suggested to me by very intelligent men that there may be a number of unexpected, or what to them would be expected, causes of mischief arising in the transport of a ship. They seem to think that there are some vibrations, or jerkings, or forces of some kind that a ship would be subjected to on a railway that she is not subjected to at sea. That feeling I know is a pretty general one. I can only attribute it to the fact that gentlemen who so think are not acquainted with the strain that ships undergo at sea. I calculated those strains for a number of typical ships some eight or ten years ago, and I ascertained some very curious facts. For instance, I would take Her Majesty's yacht, simply as a long fine-lined steamer of great speed with very powerful double engines in the center. I am speaking from memory, but I believe I am quite approximately right. At any rate, I found that that ship when at sea, in waves of such dimensions as to strain her most, and those are waves bearing a certain definite relation to her own length, undergoes at sea one-half the strain which she would undergo if supported at the two ends in that manner [indicating] on rocks. If the whole ship were unsupported except at the two ends, she would, of course, undergo a certain strain tending to crush the upper deck and to open and extend the bottom, and one-half that strain comes upon her every time she goes to sea and encounters waves of a nature to strain her. I find also that the strains of ships at sea are vastly greater than we know they sustain on shore and under critical circumstances. For example, we had a case on the Thames of an immense iron-clad ship of 400 and odd feet, which was poorly launched. She was launched until she came into a position something like that [indicating], with very nearly one-half of the ship overhanging; and the remarkable fact is that she had upon her at the time a very great deal of armor, so that she was to that extent representing a ship with weights on board and very badly placed, placed with great leverage. That ship was in that position for several weeks. Repeated attempts were made to launch her, and they failed for many weeks in succession. At last she was launched, by a process of my own. It was a very rough and rude one, but I did not mind that if it were effectual; and that was by building immense plank pontoons to roughly fit in under her quarter, and as the tide rose they lifted the ship, big as she was, upon her fore end in that way [indicating], and subjected her, of course, to the very reverse of the strain that she had been undergoing all of that time; and then we had to let her go before the tide was at high-water, so that there was a great current into which we had to launch her, and she went bounding off and heeling and throwing herself about as a boat might do; but when we got her afloat and at anchor we found that not one single butt had been strained in the least degree, and that no indication of disturbance of any kind had happened.

I should like to make a remark on the structural question. Those timber knees which I have spoken of are very exceptionable pieces of timber to get, because they have to be crooked, and it used to cost a magnificent old oak very often to get one knee out of it. In most iron ships there are more or less transverse iron bulkheads, and you will see in a single moment that those bulkheads are complete knees. They are knees of the whole width of the ship, making it strong to a degree in the region of the bulkheads, which was impossible under the system of merely putting a knee in the corner. In addition to the knee being put in the corner, it is put in this way, if the committee will kindly allow me just to explain this point. The iron ships, and a great many wooden ships, have iron decks, and are fitted in a substantial way; in this day all ships should be so fitted and constructed. If that is the beam crossing the ship [indicating], the system with the constructors and builders is to split the end of the beam and turn it down in that manner [illustrating], so that it comes in that form across the side of the ship, and before it is put there this vacant space that is created [indicating] is filled in solid at the forge with a plate of iron, so that the knee becomes firm and solid before it is put in. The result is that you are able to get a large number of rivets down, making the connection between the frame of the ship and the beam of the ship, and, as you will see, the result is a great strengthening of angle, and a great prevention of change of angle, which the ship tries to make at sea. In a word, I cannot myself see any reason at all for being afraid as to what will happen to those ships on a railway.

The next thing I would say is, that we have ships on railways, and we have them in the worst form. Nothing is commoner than heaving up slips upon which ships are pulled up out of the water. They have to take their bearing first at the bow, and gradually come up until they get upon the solid, and are then hauled up by chains. That has been

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done everywhere all over the world, thousands of times in this country, and it is now carried on to a very large extent indeed. With docks for ships of 3,000 or 4,000 tons nothing is thought of pulling these ships up, and nothing is thought of any strains that they undergo under the circumstances.

The question has been mooted, I have heard, as to the capsizability of ships upon a railroad, having regard to the sudden and violent storms that they are likely to meet with on the Isthmus. I cannot say, of course, what might happen in a storm of excessive violence, the force of which has never been calculated, for I am sorry to say that the whole scientific world is very ignorant of the effects of wind upon structures. The committee will, perhaps, be a little surprised when I say that the other day we were informed in the Institution of Naval Architects, by an officer of the admiralty who had been requested to investigate that question very thoroughly after the blowing down of a railway bridge in Scotland, that throughout the whole period of naval architecture, through the scientific period of French naval architecture, which was of a very high character at one time, and throughout all that has gone on in England and in this country, the largest sail that has ever been scientifically experimented with for the purpose of measuring the effect of wind was 1 foot square, and there had never been any experiment with any sail of greater dimensions. The one a foot square was the largest that any naval architect or engineer of any kind ever experimented with. But, at the same time, if it is sufficient on a ship-railway to provide against something like the worst hurricanes at sea, then I have no hesitation in saying that it is perfectly impossible for these ships on the railway to come to any grief from wind, because the resistance to hold the ship upright on her cradle on the railway track is, I think, very many times greater than the forces which keep her upright at sea. On that point I may mention that it is very difficult to discuss the question of the stability of a ship at sea and the power of water standing upright, but it is a fact that a ship at sea is in the condition in which she would be if all her weights were concentrated at one spot, which we will call for the moment the center of gravity. If it is a 5,000-ton ship, you can imagine a nucleus, a center, weighing 5,000 tons, and then that weight is suspended as if it were a pendulum upon a point which we give as the meta-center, and which simply is the point which all the forces of the water exerted upon the bottom. They have of course a common effect, just as all the weights in the center of gravity, justas all water pressures have one common fact and pass around one point, and the difference between those points in our largest iron-clad ships, which are some of the largest in the world, is from 2 to 3 feet.

If this ink-bottle were the center of gravity, then a height of that kind [indicating a height of 3 feet] is the point from which it is suspended, and the only security of the ship is that it is not raised up to above that point; that is to say, the center of gravity is not gone up to the meta-center. When you think of the readiness with which a ship is laid over by a strong breeze, and the fact that she is a pendulum hung upon a line only 2 or 3 feet long, and that the elevation of her weight by that short distance would capsize her, I think you will see that the forces for keeping her upright at sea are much smaller than those which could be readily supplied by the proper blocking of a ship upon a cradle.

Suppose an accident does happen on a ship-railway, I should like to ask the committee to contrast by comparison that with an accident to a lock in the center of a canal. I have been responsible for the construction of some very large docks at Milford Haven, and the amount of difficulty that we have had from the dip of the rock and from other causes in getting proper foundations for our walls has been very great, very expensive, and occuyping a long time. If you could have a canal without any locks at all, and a perfectly free flow of the sea through it, one could understand that that would be a very tempting arrangement, but when one contrasts the canal as it has to be upon this Isthmus with the simplicity of a railway, it seems to me that the advantage is all in favor of the latter.

I should like to say a word or two, if I may be allowed, upon the railway. I dare say that the most of us know that the economy of railway transport depends very much upon the conditions of the railway line. We are accustomed, as you are accustomed, to weak rails, if I may be allowed to say so. I have traveled over lines of railway in this country with the rails so weak as to draw the fastenings which held them down. I have gone along parts of lines and have seen the fastenings drawn from the rail, the rail being too light and the leverage of it over the sleeper drawing the fastening beyond it. It is not that kind of railway that would serve the purposes of a ship-railway. I should like to affirm to the committee in the strongest manner that it should be a thoroughly solid road, made with the utmost regard to inflexibility. I think myself that it should be a very different road from an ordinary railroad, and it should differ in this way: Some people seem to think that to carry a ship you ought to have a great number of rails, in a lateral sense; say a great many lines of rails. I do not think so at all. I think no ship in the world wants more than half a dozen rails and I think four might be made, if you could insure, what you probably could not do, some regard in the design of the ships to their use upon the railway. By so putting the longitudinal strength into your vessel you might do very well with four lines of rails for the largest ship, but they should be very strong of course and very large, and the locomotive should be of a corresponding character. They should have them, as we have on some of our roads, with engines that run 60 miles an hour over part of their journey. We have them exerting a pressure of 10 tons upon the single wheel, and that is done upon quite an ordinary road, such as we have in England. With an extraordinary road, such as this ship-railway ought to be, you might multiply that rate per ton a great deal, and a very slight calculation will show that if you took 20 or 30 tons per wheel, large wheels, and upon a track for the purpose, you would want a very moderate number of wheels under the car in which to carry a ship of very considerable weight, certainly not nearly so many as you could conveniently stow under the car or that you have space for.

With a track like that, and with locomotives adapted to it, there would be no difficulty in transporting ships. It would be best to avoid a very high rate of speed. It would not be necessary, I should think, to move these ships at a greater speed than 8 or 10 miles an hour, although I am quite prepared to believe that with a proper track and locomotives vessels could be transported very much faster. I think the ship-railway would be likely to develop as much as the ordinary railway has done, and create as many surprises; but in any case, I cannot for the life of me

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understand where is to enter in the danger to a ship upon a car traversing a road such as may be made, and would be made, for this purpose. I have searched for it in vain, and I cannot find the element of danger.

Captain Eads has been criticised, I am told, indeed I have seen the criticism, for having been supposed to propose a considerable overlap of the ship; that is to say, the car might be in certain cases very much shorter than the ship, so as to have the ship overhanging some 40 feet, which I think was the amount named. I do not hesitate to say myself that every iron ship that would require to overhang the car by virtue of her great length, might so overhang without any sort of risk. But I was rather sorry to see Captain Eads back slightly from the position on that question, and rather disclaim the overhanging arrangement. I do not know but that I am doing him injustice in saying that, but I have that impression. There is no sort of harm at all in it.

The cradles for these ships, when the ships are loaded, may be cars about one-eighth of the weight of the vessel, and I would be very thankful, indeed, to know that in crossing the Atlantic next week I would be in no greater danger at any time and under any conditions of weather and sea than I should be in crossing the Isthmus in one of the vessels under those circumstances. Nevertheless, the engineer who undertakes to make such a great change in the operations of the trade of the world as this would involve ought to be prepared not to tax the confidence of other people too much, and for that reason I have observed, with considerable satisfaction, that Captain Eads's proposal to his Government is that it shall give him a guarantee only in the event of his having established the terminal works at one side of the Isthmus, having laid down a track of 10 miles, and transported a ship over it. I think that he is very wise in taking that course, and I think the fact of his being able to apply the test to that extent is great proof of his confidence in the enterprise.

I would point out the fact that that proposition involves the provision of expensive works at one terminus, namely, the hydraulic lift and the apparatus. I should like to make a remark upon that, because I have met with gentlemen who, in discussing this subject, admit that the ship can be lifted, and admit that if she were on the railway she could be transported without injury; but they think there must be great danger in getting a ship from a floating position onto the track, because they say that as she passes from the supports upon which she rests before advancing onto the track and seeks to pass upon the track, she will change the strain upon her supports to so large a degree as to probably bring about an accident. I do not think there is any force whatever in that objection. In thinking it over and talking it over with one of our eminent engineers, when Captain Eads was last in England, I devised a method by which it could be done without the shadow of a risk, because the whole ship could be placed with the greatest ease upon a solid basis of stone-work or iron-work, advanced from that upon the rails, and it would meet the rails upon the cradle, at least upon the foundation upon which the cradle rested. But no such elaborate contrivance is necessary, because when the ships are lifted by this hydraulic arrangement, it is part of the system that you can absolutely lock every one of the hydraulic cylinders, and make it for all practical purposes a solid thing, and there is no need of having any extraneous apparatus at all for supporting what I may call the junction of the lifting apparatus with the road-bed. The lifting apparatus itself being hydraulic can be locked with absolute security, and similar operations to that are done daily in a thousand ways with hydraulic movement.

I do not feel justified in occupying the attention of the committee any longer, unless a Senator should desire to suggest any question, and I should of course be very proud and happy to answer to the best of my ability any question that might be proposed.

Mr. EADS. I should be glad if you would speak of the question of economy of transportation as compared with the transportation of coal in England.

Sir EDWARD J. REED. I came very near to that at one point, but I am afraid I wandered. In England I think the economy which we have got is very much the same as in this country. I think I have heard that the very lowest freight of anything whatever in this country is half a cent per ton a mile. I believe there are instances in which freight has been got down to that rate, and certainly that is the very lowest point at which freight has been carried in England, observing that in connection with that is the charge upon the return of the empty cars. Upon some of our great coal-carrying lines, where they are in competition with the sea, freight on coal has been brought down to a farthing a ton per mile, which is half a cent. None of us can possibly doubt, I presume, that if any effectual canal is to be got through the Isthmus either at Panama or Tehuantepec or Nicaragua or anywhere else, the outlay must be vastly greater upon that than upon a railway across the country; but leaving that aside altogether, the object of this enterprise is to save an enormous sea voyage around the cape. I have not gone into estimates of that cost, because it seemed to me that the case was obvious. The cost of sending this grain all around Cape Horn in any kind of a ship must be far greater than bringing the ship across the Isthmus; but if we may assume, and I think we may, that you can carry grain in a big car such as a ship is, the whole weight of the ship and car and cradle, at the price at which you can carry coal with us, then you get half a cent per ton per mile, and the cost of that comes out. How much does it add to the voyage?

Mr. EADS. Seventy-five cents a ton.

Sir EDWARD J. REED. Obviously the transport of grain over the Isthmus at that not much more than nominal rate would be an immense saving. I think myself that the time will come when we shall be surprised that we ever had any doubt about a ship-railway wherever a ship-railway was needed. I feel an interest in the matter rather personal, because, if I may be allowed to mention it, I have acquired some interests in Florida lately, and I am very anxious to see this done one way or another, that we may follow it with another in Florida for sending vessels across that peninsula and save some 1,100 miles of voyage. Seeing Senator Jones here, I hope we may be able to induce him to support that proposition.

Captain EADS. I should like for you to tell the committee how you arrived at the result of the proportion of dead weight; the proportion of non-paying weight hauled on railways with the paying weight is about the same in ships

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that it would be in our ordinary railway traffic. You have made some calculation as to the weight of the car and the weight of the ship?

Sir EDWARD J. REED. Yes; but as those calculations are set forth in a letter which perhaps the committee may do me the honor of reading, I should not like to go back upon memory for those figures. I, for my own part, have found in the course of my professional experience that the solution of difficulties generally is very simple. For instance, there are a dozen inventions in a year for different steam propellers; people are going to make a saving of 20 or 25 per cent. by altered propellers; but it comes out that propellers are pretty much alike; there is no vast difference of economy among them, and almost any propeller does for any ship if it has some reasonable regard to its leading measurements and proportions. It is the same with ships. Men have been for ages professing that particular forms of lines were vastly better than other forms of lines, but the sea does not seem to care very much about what the lines are, supposing they are within reasonable limits. It is the same thing with regard to the carriage of goods; it comes out by calculation that the expense of carrying your corn across the Isthmus by a ship is very much the same as carrying any other article in a railway car; it does not come out materially different, and that is true when you take into consideration also the cost of raising and lowering. The hydraulic system of doing that is very cheap. In an ordinary case of docking you have to fill a dock with water, which perhaps weighs three or four or six times as much as the ship, and you have to pump the whole of that weight, to handle that, and bear the expense of doing it, whereas in a hydraulic lift you have nothing in the world to do but to lift the ship.

Senator DAVIS. Has a loaded ship ever been raised in that way?

Sir EDWARD J. REED. Oh, yes.

Senator DAVIS. In what circumstance?

Sir EDWARD J. REED. I made a statement to the committee a few minutes ago in regard to Malta, where a dock of this kind was built some six or seven years ago for the purpose of accommodating ships in the Indian trade. It was found that a dock was necessary there, and one was built. At first they tried to restrict its use to vessels of as little cargo as possible, but of course ships meet with accidents with cargoes on board, and they have to resort to the dock, cargo or no cargo; and they have done this so frequently now that ships are lifted continually with very full cargoes on board. I read to the committee earlier a statement of certain vessels which have been raised with cargoes averaging in weight the gross tonnage of the ship; and I stated also, as a matter of fact, that vessels on the Indian voyage go to this dock when they are not obliged to go there. They go because of the facility which it offers, and the economy for docking and coating the ship's bottom, and enabling them to avoid the extra expense of fuel in taking a foul ship over the water.

The CHAIRMAN. How near does the load approach to the weight of the vessel as a rule?

Sir EDWARD J. REED. The cargo now has got to be often as much as the entire vessel. I prefer, however, not to trust to memory, but to refer you to my letter on that point to Admiral Ammen, as it deals with that point fully.

Senator DAVIS. You spoke of the strain of the vessel in a heavy storm being about half as much as if the vessel were suspended from either end. How is that test made? How would you know that?

Sir EDWARD J. REED. It was made in this way: The theories of the strains of vessels, which have been unaltered during the present century, were based upon the ships of the beginning of the century. The subject was investigated by a great French author, and then by a great Englishman of science; and the theory prevailed up to a certain time. When I found that it was not true, but it was very untrue in regard to ships of the present day, I established a series of investigations in order to find out what was the true law of strains in a ship at sea. I will state the method I adopted. I took some four or five typical vessels; that is to say, very long and narrow vessels, and very broad and short vessels, vessels built with very light hulls, and vessels heavily loaded with armor, &c., and I calculated the weight of each 18 inches; I divided it into very short lengths and calculated the precise weight of each of the sections of the ship of that length, taking everything I found there. If it came through an engine-room, I took as much of the machinery as came there, and as much of the masting and rigging, and everything, taking the weight of the ship for the length of 18 inches at that spot. I did that all along the length of the ship, and that gave me, of course, the distribution of the weight of the ship along its length; and with that I was able to represent in a diagram, by simply taking a line to represent the length of a ship and setting up at these intervals lines measured off in proportion to the weight I found there; that is just as you set off barometrical or thermometrical, or any other measurements. I put the ship first in still water, and calculated the buoyancy which the water supplied to each of those sections. I set that up. Then I estimated the size of wave which would most strain the ship, which it is an easy matter to do. The wave that will most strain a ship has a certain relation to her length and form. That was calculated, and the ship was put into the wave upon the assumption that, supposing the ship to be upon the crest of the wave, the conditions were for that moment what they would have been if the ship and the water, and all, were at that instant frozen in that position; you catch her at that point and take the conditions. I then put her into the hollow of a wave with the sea rising upon her extremities, and calculated in the same way the relative buoyancy; and then, of course, I got at every point the excess of weight over buoyancy, or the excess of buoyancy over weight; and by passing curves through we got curves of weight and strain, which were both equal, of course, in the aggregate, but which were very differently distributed; and in that way we found the strain at any point of the ship's length, the tendency of the ship to work either this way or that way; and some of the results were very remarkable. It had been supposed by all writers up to that time that long, fine-lined ships would tend to break by bearing in that way [indicating]; whereas they really break by bearing in the other way, and by the bottom opening; and where there is a great weight of center machinery the tendency is for the bottom to open and let the machinery out and crush the deck up, the very reverse of what was laid down in all text-books up to that time. Of course the results that were gained in that way were minimum results, because everything in the shape of motion added to the strain of the ship rather than diminished it,

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so that we were quite safe in assuming those strains to be at least the actual strains to which the ships were subjected. That was the method of calculation.

Senator MCPHERSON. Does Captain Eads's proposed railway across the Isthmus contemplate that it shall be in a perfectly straight line with perfectly level grades?

Sir EDWARD J. REED. I understand Captain Eads to propose that every section of the line shall be perfectly straight, and where a gradient is necessary that it shall be a straight gradient, and that at the junction there shall be a tilt-table to transfer the ship from one angle of inclination to another, so that the ship shall never pass over a vertical curve and in the same way a horizontal one, but that all the section of the line shall be a straight line. That I believe is what you propose, Captain Eads?

Mr. EADS. That was the proposition first made, but a further study of the subject satisfies me that there are no vertical curves that will affect the ship at all more than what the springs of the railway car would take. Turn-tables to change the direction of the road will be used, but what are known as tipping tables will be unnecessary.

Sir EDWARD J. REED. I was going on to say that I should very much doubt whether it was necessary to go to that refinement, because I have already stated to the committee that a ship may overhang 150 feet of her length and not suffer; and if she may be then hoisted up at the stern and thrown upon the fore foot, and in that way allowed to bound off the ways, there are no strains that could be brought by the passage of a slight gradient into a new inclination that would be in the least degree likely to do any harm; the springs of the car would take it up.

Mr. EADS. The change could be made from a level to the maximum grade in a distance of one, two, or three miles.

Senator MCPHERSON. I suppose a survey has been made of the proposed route, or a large portion of it?

Mr. EADS. A survey has been made of the most difficult portion.

Senator MCPHERSON. Are the grades heavy or otherwise?

Mr. EADS. On one line there are no grades greater than one per cent. Another line is a perfectly straight line for 40 miles. Through the worst part of the Isthmus there is a grade for 2½ miles of 2 per cent.—two feet in one hundred.

Senator MCPHERSON. That is very little.

The CHAIRMAN. Sir Edward, we are very much obliged to you, indeed. Your statement was very interesting and instructive.

WASHINGTON, *February* 23, 1882.

To the honorable members of the Senate and members of the House of Representatives:

Captain Eads having been unable to secure the adherence of a single practical ship-builder in the United States, went to England and secured the services of Sir Edward J. Reed, formerly a naval constructor of considerable reputation.

In the following paper I have shown how little reliance can be placed on Mr. Reed's statements, and have pointed out difficulties in the way of ship transportation over rails, and given such proofs as to the great cost of construction of a bed to support the vast weight of loaded vessels—this cost being at least three times more than that of a canal across Nicaragua, while the cost of maintenance and operating the railway would be five times greater than that of a canal—as will convince all thinking men of the impracticable character of the railway enterprise.

S. L. PHELPS.

NOTE.—Special attention is invited to the letters of ship-builders, owners, engineers, and underwriters, in the appendix.

THE TEHUANTEPEC SHIP-RAILWAY SCHEME.

A full discussion of the projected ship-railway over Tehuantepec calls for knowledge and experience of highly varied character, more so than falls to the lot of any individual, and an endeavor to ascertain the requirements of such a road involves difficulties of a complex nature. The mere possibility of transporting such a weight as a ship represents over rail, is one thing; to do it with entire safety to the ship and at such cost in money and time as will make the undertaking a practical one, is quite another thing. The first is a problem in engineering; the other embraces knowledge belonging largely to other pursuits.

A ship railway across at Panama was discussed by people on the Isthmus and in California as early as 1850. In 1858 and '59 quite an excitement prevailed in certain circles over a project for such a road across Honduras, and, subsequently, a company was actually organized in England for its construction. This afterwards led to an investigation by Parliament into the affairs of the then collapsed concern. This old idea has now broken out anew in this country, the field for the work having been transferred, however, to the territory of Mexico.

Without aiming to treat of those difficulties in railway engineering which must be met and which are very far from now being comprehended or in any sense solved, it is possible to present some practical points of easy application that will serve to indicate how little even Captain Eads himself understood of the subject when pressing his scheme upon the last Congress, and how far he is still, after having been driven from one device to another, from realizing the undertaking he aims to promote.

A thoughtful person will quickly discover that the transportation of ships by rail is a proposition belonging to three distinct professional studies and pursuits. It embraces the knowledge and experience of the seaman, the engineer, and the ship-builder, and in importance in the order named, for the safety of the ship is the first consideration.

The constructor of a vessel would not be selected to secure its safety at sea, while an engineer is as likely as

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otherwise to be wholly ignorant of the principles of ship construction. The seaman, in the perpetually recurring contests with the dangers of the sea, presented in forms as varied as are the waves he battles with, learns more of the endurance and capabilities of the ship under him than the man who designed and constructed it could ever know. Instinctively seamen feel the perils of land for a vessel. They know that in its own element a minimum of power is required to move it easily and rapidly, and that the instant it touches ground it becomes movable only by the exertion of prodigious force; that in the water it is the strongest of structures for its weight, and out of the water is the heaviest of structures for its strength. They also learn of the perils and dangers lurking in the dock and ways, for all seamen of experience have known of disaster in some form upon cradles.

Mr. Eads has published a pamphlet of testimonials. It is a curious fact, and a significant one, that not an American ship-builder appears in the list. There are a great many men in this country, and many very able men, engaged in the construction of iron vessels, but they, to a man, oppose the idea of ship transportation by rail, as do also all engaged in their construction of wood. The names of two naval constructors appear in the list. One of these men is a ship-carpenter, and in no sense a builder of ships; the other is a draughtsman, and a very good one. Their letters are a sufficient index of the value of their testimony.

Captain Eads points especially to the letters of three engineers—Garay, Fuertes, and Williams; and his whole pamphlet in some sense revolves about Mr. Reed, ex-English naval constructor, as the central figure. If the evidence of these men breaks down, the whole fabric tumbles.

No one questions the practicability of lifting ships by hydraulic devices, and many of the pages of the pamphlet might have been spared. The eagerness of English firms to contract to lift vessels, when there is a shadow of a chance, is well displayed in several of the letters or statements.

A contrast of the two letters of Garay and Fuertes at once disposes of the gushing production of the latter, who falsely states that grades of from 25 to 35 feet per mile could be found in one of the passes. Mr. Fuertes was the engineer in the survey of the ship-canal route over Tehuantepec. On page 33 of Shufeldt's report of the survey is this statement by Mr. Fuertes: "On the Pacific side it is necessary to descend with sixty-three locks from the summit of La Venta de Chicapa, and this must be done in 8 miles." These locks were upon a sharp curve, the distance gained in a right line perhaps 6 miles, and the difference in level overcome 638.8 feet, or over 100 feet per mile gained. He is the man who could so locate a canal in a country where grades for a ship railway—which must be upon straight lines, and cannot change direction by use of turn-tables on an incline—of 25 to 35 feet per mile can be found!

Mr. Garay disposes of all this nonsense, in defending himself from another statement by declaring that the line he had laid down does not involve more than 2 per cent. grades and a cut of only 312 *feet depth*. Such a grade is 105.6 feet per mile.

Mr. Eads, in publications over and over again, has asserted the greatest grade would not exceed 1 foot in 100 in any portion of his proposed roadway, or about 53 feet per mile. The depth of cut and the grade now admitted by him are quite sufficient, and offer difficulties large enough without pushing inquiry further.

There is not enough of or in Mr. Williams's letter to make anything out of it.

Generals Gillmore and Beauregard, for the most part, affirm certain engineering possibilities. Neither is a railway engineer; neither knows anything about ships. It is singular to find the readiness of men, very able in their professions, to express opinions and positive views of things foreign to their experience.

Compelled to go to England to find a ship-constructor willing to approve his plans, Captain Eads, rather unfortunately for himself, struck upon Mr. Reed, ex-naval constructor, out of employment. This pamphlet well displays how that gentleman busied himself in procuring indorsements for the railway scheme Having since come to this country, he has been going about with Captain Eads to talk up the ship-railroad, being presented as Sir Edward J. Reed, M. P., and I know not what other titles, all, however, honorable testimonials to his skill and ability.

Before coming to this side he wrote the paper I find in the pamphlet, addressed to Admiral Ammen, but in fact intended as a reply to my review of Mr. Eads's article in the March number of the North American Review. Prior to a discussion of Mr. Reed's statements, it will be advantageous to give some account of Mr. Reed himself, who, in the beginning of his career, was a newspaper man. Having ability and a turn for other pursuits, he became a naval constructor, and, in the earlier construction of iron-clads, enjoyed the confidence of the English Government in that capacity. Some seven years ago he found it advisable to resign the position of naval constructor.

In an attack upon the plans of the Inflexible, a vessel costing $5,000,000, and built on designs of Mr. Barnaby, whose name I find in this pamphlet, Mr. Reed stated he had prepared designs and a model of the vessel in his own office and gone over all the calculations, and that, like two then under construction for the Italian navy, it would be dangerous as a fighting ship, because liable to capsize. Such changes were adopted then as made Mr. Reed practically the architect of the ship, but neither he nor Mr. Barnaby could learn, with all this care in estimates of the weight and placement of load, that the craft ready for sea would weigh 800 or 900 tons more than their estimate as indicated by her draft, which is 2 feet greater than expected. They did not learn that she would have an eccentricity in steering, and would not make the speed anticipated by 20 per cent.; yet Mr. Reed can tell you the weight of a ship-car, a thing never yet constructed.

Considered from the standpoint of view of these constructors, the ship is a costly failure.

Mr. Reed designed and became the champion of the Bessemer Channel steamer, which was to cross the Channel in sixty-five minutes, and the cabin of which, being hung on pivots, was to spare the world, traveling first class, all misery in the hateful chop-sea of that narrow water. But the ship would not go, it drew *two feet too much water*, and the cabin, once in motion, would not stop. (See Transactions Institution of Naval Architects, April 16, 1875.)

Admiral Popoff conceived the idea of circular ships. Mr. Reed became the friend of the Russians in these constructions, supported them and advocated them. The Lavidia (length, 230 feet; beam 130 feet), the greatest failure of

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our day, was the legitimate outgrowth of ideas expressed by Mr. Reed in a paper read before the Institution of Naval Architects, March 22, 1877. (See also Transactions same institute, April 6, 1876.) Those circular ships over which he labored are monuments to pet theories and tangential departures from well-established ways.

This is the man, one of ability, but unsafe and unreliable to follow, who is brought to this side to set up an opinion against that of every ship-builder in this broad land, to say nothing of seamen of every grade and condition in life.

On page 36 of the pamphlet Mr. Reed expresses the opinion that vessels weighing, with cargo, 4,000 tons, the extreme size proposed by Captain Eads in his final trial, are large enough to conduct American commerce in voyages which, between our own ports on either side of the continent, would become 4,000, 5,000, and 6,000 miles in length, or nearly twice the distance across the Atlantic. But Mr. Eads should have known and informed his supporter that American vessels of much greater weight are already trading on that line, and that wooden vessels, under the Yankee flag, still sail from Pacific ports displacing, with their grain weights, over 5,000 tons. Can it be Mr. Reed did not know that one of the finest fleets in the world trades with the west coast of South America?—a fleet composed of seventeen steamships displacing from 7,000 to 9,000 tons, and twenty-five others, hardly one of which would not be too large for Captain Eads's final trial.

These facts show what class of vessels *owners* think are needed for such voyages. But it suits the views of English ship owners and builders to cramp the energies and enterprise of American builders, who are under the disadvantages of more costly labor and of duties upon materials, in their endeavors to construct American bottoms.

I shall show by practical illustration how wide Mr. Reed was of truth when he spoke of the ease with which the railway could be extended to take larger vessels than those for which it was originally designed.

On page 37, without reference for authority, and by a most refreshing *ipse dixit*, Mr. Reed announces that a car to carry a vessel of 4,000 tons displacement would weigh about 500 tons, and proceeds to make statements based upon that assumption. I shall now turn over several pages of learned discussion as to the facility with which ships can be lifted by hydraulic appliances, and about strains of ships in water, the first being a feat no one disputes is done and can be done, and the second having no bearing upon the real question at issue, to find, on page 42, a statement about the hauling power of engines. He says Mr. Bramwell stated that locomotives could draw 800 tons at slow speed. What is the grade? None is stated. Eight hundred tons implies forty loaded cars. It is certain no one in this country ever saw forty loaded cars in one train drawn by one locomotive over an ascending grade of *five* feet per mile, and American engines in all competitive trials have driven English-made ones out of the market. Before Mr. Reed was a table of the effective traction-power of locomotives—one he could have verified—and for 40 feet grade it gives 218 to 292 tons. Of course, for a ship railway a locomotive must be adapted to the worst conditions of haul, and therefore 218 tons is the correct figure. But the grades over Tehuantepec reach to 105.6 feet per mile, for which the traction-power, per table, is 93 tons. See Appendix (15). Now, how many engines will it require, at that rate, to pull the ship of 4,000 tons weight and the heavy car carrying the load? Mr. Reed *says five or six would be sufficient for the great majority of vessels.* Seventy American ships sailed from San Francisco, grain laden, during the last six months of last year, the lightest vessel of the number weighing, with her load, 2,172 tons, and there were, as before stated, those that ran up in weight to between 5,000 and 6,000 tons. It seems absurd to spend time over an assertion so ill-considered as Mr. Reed's.

Then, on page 43, he goes on to picture the great cheapness of the haul over Tehuantepec. The Great Eastern Railway takes coal at one-half cent a ton per mile, and consequently Mr. Eads can transport ships and cargoes at corresponding rates, and says, "My weight of car added to the weight of hull will make a weight bearing the same proportion to the cargo carried in the ship that the coal car in England bears to the coal carried, that is as 4½ to 7¾." Mr. Reed writes as an expert and as of authority.

Mr. White, author of the text-book on Naval Architecture used at the British Naval School, where he is instructor, sums up, on page 415, the weight of an ordinary steamship of 5,000 tons displacement, and shows that the hull, machinery, and supplies would be, as nearly as may be, equal to the weight of cargo carried. On page 370 is the proportional weight of wooden vessels to cargo carried. The mean is 40 per cent. When steamships designed for passenger traffic are in question, the hull, machinery, and equipments become much heavier. The Colon, displacing 4,000 tons, carries 1,800 tons cargo. The Tokio displaces 9,000 tons and carries 4,050 tons dead weight. The Germanic's weight is 5,500 tons, and she carries 4,500 tons. See Appendix (14). The hull of the Servia, without machinery, weighs 5,200 tons and carries, cargo and supplies, 6,500 tons. The City of Rome, ready for sea, without load, weighs 8,000 tons, and carries dead weight of cargo 5,500 tons.

Based upon such data, the English coal car, if in like proportion to its load of 7¾ tons, would weigh—

	Tons.
Compared with wooden ships, weight of car for 7¾-ton load	4.9
Compared with ordinary steamers, weight of car for 7¾-ton load	7¾
Compared with passenger steamers, weight of car for 7¾-ton load	9¾

That is, ships weigh much more in proportion to cargo carried than does Mr. Reed's coal car, and steamships weigh as much or a good deal more than their loads. When the weight of the car is added to that of the vessel the discrepancy is largely increased.

Thus it is shown that this part of his calculation is utterly worthless.

The basis he assumed is the cost of hauling coal on a level road in England. Are we to understand that, had the road been constructed solely for carriage of coal, the Great Eastern road could earn a profit on one-half cent per ton per mile? That road carries millions of passengers, mails, express matter, fast freight, and a host of other things,

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paying large profits. The tracks not being wholly occupied, it pays to haul coal at little more than the cost of traction.

Mr. Reed furnishes proof of the absurdity of his assumed weight of car by the very example of weight of coal car to load, being about 52 per cent.

An English coal car is the simplest form of railway transportation, being a little sheet-iron hopper mounted on two axles and four wheels. It bears the least proportion to load carried of all cars. In this country ordinary freight cars range in weight from three-quarters of load to as much or more than the load. The English coal car is about 52 per cent. of its load. In the competition that compels the carriage of coal at one-half cent per mile, it is perfectly plain managers would reduce weight of car and add to load if they dared do it. Hence we may assume that the ratio of weight is brought down to the lowest point, and that cars made wholly of iron must weigh in proportion to load the ratio named. There are no cradles, no buffers, no hydraulic devices, no props or supports to hold a hull towering 40 or 50 or more feet above the tracks, with houses, rigging, and top hamper far higher still, the whole to be supported in the unequal movements over uneven tracks and to resist the power of gales of wind.

Thus, without data as to cost of road and the consequent returns necessary; without considering that the ship railway earnings must be from freight alone; without knowing the amount of business in proportion to investment; without taking into account grades which, if they existed on the Great Eastern road, would have prevented the carriage over it of a single ton of coal; without any of the requisites to a proper estimate of the cost of carrying the ships, he deduces a rate of 75 cents per ton, but, as the ship railway is to be at Tehuantepec, agrees the rate shall be doubled and become $1.50 per ton for the transit. That is one cent per ton per mile of cargo on board, or less than the average rate for freight over the great trunk lines and their connections to the Mississippi River (see Nimmo's Railroad Problem, October, 1881), where the average is 1.07 cents per ton. At what rate could these roads carry freight, were that their only business? Even as it is, they by no means earn dividends for all their stockholders, notwithstanding their better-paying business to help in that direction.

The roads from Chicago to New York, with a running distance of 900 miles, cannot compete with carriage by lakes and Erie Canal, a distance of 1,400 miles. The rate by rail is 60 per cent. greater and the distance 500 miles less.

The New York Central and Hudson River Railroad carried, in 1880, 10,533,038 tons of freight, receiving therefor $22,199,966. The average rate per ton per mile was 0.88 of a cent. The rate prevailing on the Erie Canal the same year was 0.49 of a cent. (See Nimmo's Report, Appendix, Table 37, on the "Railroad Problem.")

Had the freight transported by the road been carried by the canal, the cost would have been $12,361,363, or a difference in favor of the canal of nearly $10,000,000, and representing the increased cost to the consumers of the articles carried, or to the producers of them.

Suppose the distance by water between Buffalo and New York had been one-third that by railway, the cost of transportation by the shorter route would have been proportionately reduced, and the total would have been between $3,000,000 and $4,000,000 as against $22,000,000 by rail.

The Nicaragua Canal will be 53 miles long, the remaining distance over that isthmus being open and unobstructed navigation. The Tehuantepec Railway would be about 150 miles long (see Reed's paper); therefore the comparison applies as made between the railroads and an Erie Canal one-third their length. The ship railroad must, in the first instance, transport the ship not only three times as far, but must do it per mile at nearly twice the expense of the canal, or altogether at six times the cost. Furthermore, the ship itself must go as cargo, there being still a car as in case of all other railway carriage.

With no knowledge whatever as to the expenses of canals, Mr. Reed, on page 44, expresses the opinion that the railway would prove more economical than a canal. Such wild assertions would almost make one think him in the pay of de Lesseps and in Panama interests.

The expenses of the North Sea Canal are about $75,000 per year (see Reports Consuls, Amsterdam); and as 2,519 vessels passed through it in 1877, when a full report was made, it amounted to 6½ cents per registered ton of shipping. The canal is 16 miles long, has an expensive artificial harbor and two systems of locks, the level of the canal being below that of the sea.

The Suez Canal, 100 miles long, entailing dredging to the amount of about 1,500,000 cubic yards yearly, costs for maintenance, management, and operation yearly from $830,000 to $860,000, being about 11 per cent. of its gross earnings, or about 20 cents a ton register of the shipping passing through it, towage included. Were the weight of cargo and ship taken into account, as must happen with the railway, the rate per ton displacement for the Suez Canal would amount perhaps to 8 cents and that in the North Sea Canal to 3 cents.

The Suez Canal shares have risen from a par value of 500 francs to more than four times that amount, because of the great profit in the investment.

Mr. Eads in his bill fixes 50 per cent. of the gross receipts to be taken as the actual expenses of the road. This applied to the Suez Canal would have made its expenses $3,971,798 as against $863,000, which they amounted to in 1877. Had there been a ship-railway instead of a canal, shipping would have been taxed $3,108,000—the difference of the two costs—for the privilege of enjoying the risk of transportation on wheels where no vessel was ever designed to be.

I shall touch lightly upon but one or two more points in this remarkable letter of Mr. Reed.

I find a statement on page 43 respecting the difference in carriage of the Tokio and City of Rome, he stating that additional length of car is what is needed to carry the heavier ship. The wheels are placed by Captain Eads 3 feet apart along the rails, each wheel to bear 5 tons. Consequently 3 feet of the middle of the ship would rest upon a row of wheels across the tracks. Three feet of the Tokio weighs about 91 tons, and three of the City of Rome 107

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tons, car not included, the one requiring eighteen wheels for ship alone and the other twenty-one wheels, and, of course, the same number of rails.

On page 42 Mr. Reed states that I had limited the weight per wheel to 5 tons and contended for that as a limit—a gross misstatement; for throughout the article I was quoting Mr. Eads limitation of 5 tons and showing that he could not carry ships on twelve rails with that limit to each wheel. It was also clearly explained that there is not a paragraph in Mr. Eads' paper in which there is not one or more erroneous statements.

In a recent number of The Engineering, published in London, is an article evidently a production of Mr. Eads, in which the limit of weight per wheel, for the first time, is put up to 10 tons. Mr. Reed states that the driving-wheels of engines sometimes are loaded to 10 tons, which is wholly imaginary. In the article before him was a table of pressure of all American models, and but one had so large a pressure as 5½ tons, and the mean of all was 4.7 tons. Our locomotives are quite as heavy as any in England. (See Appendix 13.)

I think enough has been stated to show the unreliable character of Mr. Reed's views, opinions, and statements.

It was before necessary to mention the weight of 3 feet lengths of cross-sections of ships, because upon that weight must depend the number of wheels and rails necessary, for Captain Eads puts his wheels 3 feet apart along the rails. While the beam and depth of the submerged sections measure the average displacements of sections of the hulls, they do not measure that of each and any length of three feet in the central part, because engines, coal, and cargo give excess of load in some portions, leaving excess of buoyancy in others, and resulting in unequal distribution of weights. Without knowing the weights, etc., the accurate load in any portion cannot be determined, and the computation would be difficult. It can only be asserted that the loads in places will be larger than obtained by means of the simple submerged portion of the ship. Where the heavy machinery falls, there the ship car would have a greater load and a more destructive pressure. This would demand a large safety limit in fixing the weight per wheel when at rest.

In his Review article Captain Eads stated that the wheels might be subjected to double the normal load because of inequalities in the road-bed passed over. In the transportation of steamships a great allowance would become necessary because of the weight of machinery, as above stated; but merchant sailing-vessels, it will be shown, offer examples of quite as great loads per cross-section as do great steamships like the Tokio, because of the breadth and depth of cargo stowage.

Before the number of tracks can be determined we must fix upon some weight of car. It has been seen that the little English coal car weighs 52 per cent. of the load it carries; that American freight cars range from three-fourths of their load up to as much or more than the load carried. The Georgetown pontoon, with no requirement but the slow movement over 500 feet, when drawn by a fixed power (200 H. P.), aided by counter-weights, and carrying a flat-bottomed canal-boat resting upon the car floor, weighs about as much as the loaded boat carried. It is thus clear that the car to transport ships must be a very heavy affair. But assume that it will bear to its load about the ratio of the English coal car, say 60 per cent., then for a 4,000-ton load the weight would be 2,400 tons.

There sailed from San Francisco in the last six months of 1881, amongst many other vessels, the Edward May, the Sterling, and the J. B. Walker, loaded respectively with 1,279 tons, 2,559 tons, and 3,295 tons, all American ships. Their total weights, in the order named, were 2,132 tons, 4,265 tons, and 5,491 tons. Three feet middle lengths of these vessels weighed, respectively, about 47 tons, 80 tons, and 89 tons. Their transportation, at 5 tons per wheel, would consequently require for ships alone 9.4 rails, 16 rails, and 17¾ rails. Adding 60 per cent. weight of cars, the whole number of rails necessary for each would be 15 rails, 26 rails, and 28 rails.

According to the Engineering article, Captain Eads has already doubled the limit of pressure per wheel, making it now 10 tons; but it will be seen that the 4,000-ton vessel would still require more than 12 rails. He might as well put the normal pressure at 20 tons as 10 tons, and probably will now that it becomes necessary, because 10 tons for each wheel on 12 rails will hardly suffice for grain carriers of medium weight.

What prevents the Great Eastern Company from putting more coal on a 4½-ton car with its four wheels? The weight of coal and car give but 3 tons pressure per wheel, the coal alone not imposing 2 tons, while the pressure on the road-bed covered is only about 380 pounds per square foot and the trains move slowly. Why is a locomotive, with tender of 40 tons weight, the engine weighing 25 tons, considered a maximum weight, and used only in urgent need?

Mr. McAlpine, in his letter of June 3 last (see Appendix) explains this—and no one will question that William J. McAlpine stands in the front among railway engineers—in these words, quoting from that letter: "Of the inequalities of the surface of the rails of the best built railroads in the world, causing constant concussions with the maximum weight of 40 tons, and would be multiplied by weights of 5,000 to 10,000 tons, sufficient to destroy almost any track that could be built (the concussive effect being as 125 or 250 to 1); hence a speed of not exceeding one mile an hour would be necessary, or 150 hours for crossing the Isthmus." On American freight cars the normal pressure per wheel is 2½ tons, and on the driving-wheels of locomotives 4.7 tons—one pattern going up to 5½ tons. It is the destructive concussive effects that destroy. A person standing by a passing freight train moving 15 miles per hour may hear these heavy blows in infinite number. Mr. McAlpine mentions the mechanical impossibility of equally distributing the weight of the ship, cargo, and cradles "on 1,200 wheels over six ordinary railroad tracks, *so that sometimes a hundred or less number of* wheels must carry the whole load; and hence that the substructure must be immensely stronger than any railroad ever built." In both these views Mr. A. Savary, in his letter of February 10, 1881, fully concurs. (See Appendix.) And special attention is invited to the letter of J. F. Rowland, of the Continental Iron Works, New York, also in the Appendix.

In this connection it may be well to refer to the experience at the Georgetown Incline, where there are four tracks and thirty-six wheels to carry a loaded canal-boat, weighing, with load, 140 tons. The steel rails—the best obtainable—are sometimes crushed. These rails rest upon 6-inch by 12-inch oak timber laid in cement upon stone

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walls built up from solid rock and leveled with the utmost obtainable precision. The oak timbers are shivered while the rate of motion is very slow.

At the Washington navy-yard marine-way the rate of motion in hauling up vessels is so slow as to be almost imperceptible to the eye. Recently, in taking out a vessel weighing near 1,100 tons, it became necessary to supplement the hydraulic engine—pump worked by a 75-horse-power steam engine—with powerful purchases, the falls of which were taken to capstans manned with 300 seamen, and two weeks were occupied in getting the craft out. The connection between the engine and car is by 3½-inch diameter iron rods. These broke repeatedly, and one capstan was twisted in two. All load had been removed from this vessel. The inclination of the tracks is equal to 275 feet per mile, and yet great difficulty was experienced in moving the vessel down them, even with the aid of the capstans and purchases. The weight per wheel was 7½ tons.

When marine railways were first projected, their capabilities were thought by engineers to be far greater than experience has justified. There are mechanical difficulties not understood and as yet not provided for by the best engineering skill, which preclude the practical use of such railways with heavy vessels or loaded vessels. A three-masted schooner loaded with 600 tons of cargo was taken upon the ways at one of our large ship-building yards, and while the total weight was not considered objectionable, it was massed so that the vessel was got out of the water with extreme difficulty and at the cost of rebuilding the tracks and of injury to the vessel itself. In short, the tendency of engineering in that direction is the abandonment of marine ways in favor of docks, either permanent or floating, from which the water is pumped. (See Savary's letter; also pages 17, 18, 19, and 20, in Appendix.)

Taking what McAlpine states and the experience at Georgetown into view, will it not be suspected that even 5 tons is a high limit of weight per wheel for safety? The ship weighing 4,265 tons and the car together would put 6,824 tons on the track, and the number of wheels required would be 1,365 at 5 tons each. Let the whole load fall on 100 of these wheels, as McAlpine says may happen, there would be 68 tons on each wheel. Should the normal load per wheel be increased to 10 tons, then the pressure would become twice 68 tons, or 136 tons per wheel. Assuming that the transporting car weighs nothing, there would be 42 tons per wheel in the first instance and 84 tons in the second. It is not considered worth while to waste more time in showing that the number of tracks must exceed six or twelve rails, and largely exceed that number.

Thus, to carry the ordinary grain ship there must be at least sixteen rails, and such further number as are necessary to carry the car itself. Shall this be taken to be 25 per cent. of load, half that of the little English coal car to its load? If so, the rails must become twenty. If the ship car be taken to be 50 per cent. of load, the rails required would become twenty-four, and so on. In any event the cost of the roadway would be largely increased beyond that of a road of twelve rails.

Twenty-four rails across the Isthmus would be the equivalent of 1,500 to 1,800 miles of single-track road, depending upon where the Pacific port might be.

The ordinary American freight car gives a pressure of about 160 pounds per square foot of ground covered. The 4,000-ton ship would give ten times that pressure, and the ship and car together, when at rest, one ton. Under the American car are eight wheels. Were it possible for the whole weight to fall upon one of these wheels it would bear but 20 tons; but it is impossible for it to fall upon less than four of the wheels, making the load on each five tons.

This leads up to a point most carefully avoided by the railway advocates, the fact that bodies moving over plane surfaces practically rest upon few points, because a true plane cannot be maintained under them. The American car rests upon two central points in the center of a system of four wheels, placed at each end of the car. Each system of wheels being independent, each of the four wheels bears an equal pressure when at rest. In motion, it is possible two upon the same side may bear the load. It often happens that first-class passenger cars have six wheels at each end, and but four of the six carry the load. Two on either side run upon the higher surfaces of the rails while the third passes over depressions, and hence the comparative ease in motion of such a car. A ship on a car would practically rest on few points of the track during the Isthmus transit, points momentarily shifting, but always producing great strains on wheels and axles, and, in the carriage of a ship, any attempts to distribute load by hydraulic devices would result in local strains to the hull, of which Mr. White makes mention in quotations that will be given further on.

This is but another way of stating Mr. McAlpine's proposition, that one hundred or less wheels will bear the entire load at times. Where such weights should fall upon the wheels the upward thrust upon the ship could not fail to produce serious strains to the hull.

It follows that enormous pressures must and would fall upon very limited areas of road-bed; that the medium-sized grain carrier, not taking into consideration the car carrying it, would bring 42 tons upon a single wheel among 1,300; or should the normal weight per wheel be made 10 tons, *then of 84 tons.* What manner of road construction would hold under such a pressure, delivered at the point of contact of a wheel with the rail, and with concussive blows?

It is quite useless to follow up this line of thought except to apply it as the most important factor in estimating the cost of the bed of a ship railway designed for such loads.

The cost of the foundation of the Brooklyn navy-yard dock was at the rate of $500,000 per mile, and Mr. McAlpine states that the ground is firmer than that of the first 60 miles from Minititlan on the ship railway line. But the dock was designed to support 3,000 tons entirely at rest. The road in the transportation of the 4,000-ton ship would be subject to pressures per square foot, with the train going 6 miles an hour, fifty to one hundred times greater than the dock is made to bear.

Had the dock foundation been designed for such weight and concussive action, its cost would have been much greater.

The foundation of the Washington Monument can under no circumstances be exposed to more than 5 tons press-

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ure per square foot. It is 20 feet deep below the natural surface and mostly of hydraulic concrete. It is held that from one ton to one and three-quarters of a ton is as much pressure per square foot as can be safely allowed under the best buildings; but the weight is at entire rest.

The Great Eastern when launched weighed 12,000 tons and rested upon 20,000 feet of ground. This was heavily piled and large timbers secured upon either side of the pile-heads. Over all were 2 feet of concrete, and on this a covering of oak timber 12 inches thick, across which the ways were laid.

With these examples in view, and having in mind also the vast weights liable to fall upon any point of a road-bed from 40 to 50 feet wide, as it must be to carry grain ships, it appears certain the cost per mile of the 70 miles between the Uspanapa and the Upper Coatzacoalcos Rivers, for the foundation alone, the superstructure being left out of the calculation, would be an immense sum. Mr. McAlpine says: "I have described from personal surveys the route which his (Eads) engineer has selected, and have spoken of the enormous cost and difficulty of carrying his roadway across the *deep swamps* of one-half at least of the first 60 miles, from near Minititlan." Mr. A. Savary says the "grading and superstructure for a railway of sufficient strength to sustain the weight of a 3,000-ton ship must cost more to begin with than a canal of equal capacity." (See Appendix.)

Over such a country the cost of the road-bed alone would be far more than the cost of a canal to carry the largest steamship on the Atlantic, and more, mile for mile, than the canal across Nicaragua, where the deepest cut between the lake and the Pacific is not *half the height of the hill on which the Capitol stands*, and the greatest elevation to be overcome *not that of the Senate Chamber floor above the Potomac.*

Then, the mountain country over Tehuantepec is rough; there would be many cuts and many fills; rapid and turbulent streams to pass, and, in the descent to the Pacific, a cut of 312 feet to secure a grade even as favorable as 105.6 feet per mile, a grade considered inadmissible on a first-class railroad.

In the fills, stone foundations for each one of the tracks must be constructed, resting upon the solid rock beneath, or upon piling, and everywhere that rock is not reached expensive foundations must be built. I was in a great cyclone on that part of the coast in 1866, in which 27 inches of rain fell in forty hours. The floods that followed upon it swept whole forests to sea, and with the *débris* were jaguars, deer, and other wild animals, helpless in the resistless torrents. What kind of road-bed would have safely borne 4,000 or 6,000 tons in the midst of such a storm, or following upon it?

It is surely not necessary to pursue this subject further. The superstructure, the lifts, the cars, the sidings, the turn-tables, the fixed engines, the traction engines, the harbors, the rivers, the lagoons, each and all are very expensive items going to make up the total cost of the railroad.

On a canal, even the locks can be easily worked by a turbine wheel driven by water taken from the canal itself, thus avoiding expensive steam machinery. The ship railway will be several times longer than the Nicaragua Canal, and must cost several times more than the whole cost of the canal, and consequently *there will be a much larger capital on which to earn dividends*, while the cost of maintaining and operating the road would be *five times greater.*

The annual cost for maintenance and operating the New York Central and Hudson River Railroad in 1880 was 59.04 per cent. of gross earnings; for the Erie Railroad, 62.29 per cent.; and for the Pennsylvania Railroad, 61.80 per cent., the mean being about 61 per cent.

Mr. Eads, in his bill, fixes upon 50 per cent. of earnings for expenses. The Suez Canal, 100 miles long, is conducted for a little over 10 per cent. of earnings, and would be for less but for the great expenses ($164,000) in the Paris office. The North Sea Canal, passing 2,500 vessels through two sets of locks and 16 miles of canal, costs but $75,000 a year.

The estimated cost of the Nicaragua Canal, *based upon actual instrumental measurements*, including lake, river, and harbor work, is $41,000,000. Assume its final cost to be $75,000,000, its length being 53.15 miles.

Six per cent. on $75,000,000 is	$4,500,000
Add for all expenses	600,000
Total earnings necessary for 6 per cent. profits	5,100,000

Captain Eads estimates his railway to cost $75,000,000, the estimates not being based on actual measurements except for small part of the line. Let us assume that his road, equipments, and all, would *cost no more* than his estimates, then—

Six per cent. on $75,000,000	$4,500,000
Add for expenses 50 per cent	4,500,000
Amount of earnings necessary for 6 per cent. profit	9,000,000
The amount for the canal was	5,100,000
Difference against the railroad	3,900,000

Take it the other way, the business being supposed 3,000,000 tons—

The yearly earnings, 3,000,000 tons at $2.50 per ton	$7,500,000
Deduct for expenses 50 per cent	3,750,000
Net earnings	3,750,000
For the canal the net earnings would be	6,900,000
Difference against the railroad	3,150,000

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But it is worth while to mention that the ship-railway grant would admit of a charge per ton *three times greater than* $2.50 per ton. Should the real cost of the road, or such as safe men would probably estimate it to cost, be taken in the above estimates, the showing would be far less favorable to the road.

But perhaps the friends of the railroad may claim that the estimates for canal expenses *are too small*. The North Sea Canal, 16 miles long, with two sets of locks and an artificial harbor, standing on a sand beach in the North Sea, costs yearly $75,000, and has a large business. The Suez Canal, 100.15 miles long, through which over 4,000,000 tons of shipping is now passing yearly, costs for management, maintenance, and operation $835,000 to $860,000 yearly, including cost of towing vessels and of 1,500,000 cubic yards of dredging.

The Louisville and Portland Canal, with two large locks, tug, dredges, and dock, costs, less dredging, $30,000 yearly. The Saint Mary's Falls Canal, having the largest lock in the world, costs, it is estimated by General Weitzel, $25,000 yearly.

These different works give for the cost of 53 miles of canal and harbor work, allowing $20,000 for each of the twelve locks in the Nicaragua Canal, a mean result of $544,873, as follows:

Suez Canal	$666,513
Louisville and Portland Canal	465,204
Saint Mary's Falls Canal	596,374
North Sea Canal	451,402
Mean	544,873

This should be satisfactory evidence as to the yearly cost of the Nicaragua Canal, and that it would not exceed $600,000. At all events, in no case can the Secretary of the Treasury allow more than $1,000,000 for all expenses.

Captain Eads has overlooked the destructive effects of earthquakes. When they are mentioned, however, he denies their existence on the Tehuantepec Isthmus. But they are quite frequent on that Isthmus, and while they would probably not injure the road-bed, they would destroy any shipping on the road mounted upon cars.

This will the more fully appear from accounts of earthquakes (see letter, Appendix) given by Dr. Thomas A. Streets, surgeon U. S. N., who was a member of the Canal Survey in Tehuantepec, and by Commodore Shufeldt, page 106 of his report of that survey.

Dr. Streets says there were four earthquakes between November and May, 1870–'71. One occurred in February at La Vente de Chicapa, which is at the foot of the pass. The doctor found it necessary to seize hold of a gate-post to prevent falling. Some time previously the house he was staying in had been rent in an earthquake. In Shufeldt's report I find the following: "There (Chimalapa) the doors and windows of the house we occupied were unhinged; a section of the adobe wall over the window was broken in; portions of the plastering and some of the thatched roof were thrown down; our animals were thrown on their knees, and were unable to regain their feet; and an old house, with its long grass roof, near which we had been sitting, shook like a *load of hay passing over a stony road, which, indeed, it much resembled.* It was exceedingly difficult to stand erect, and we found it necessary, in order to maintain this position, to hold fast to an old stone wall which happened to be near. The shock, which lasted sixty-four seconds, came from the east and passed to the west, and was preceded by a loud rumbling noise. The motion was wholly of the vibratory or horizontal sort."

I was in an earthquake in Chili of severe character, in April, 1851, and was in position to notice the ridge of a long, low roof which had a wave movement, as if imparted by the passage under the building of surface swells, precisely similar to the "dead swell" in water when a calm suddenly springs up over a lake. One I experienced was like the tossing one undergoes in a railway car off the track and running over the ties.

The vast pressure such movements would cause to small sections of car and ship in quick succession would destroy both ship and car. Consider a ship at such a time mounted upon a car, the hull towering 40 or 50 feet above the road-bed, or three or more times higher than the low, yielding adobe walls of the native houses, and reflect upon the chance it would have when shaken about "like a load of hay on a stony road," the car being twisted under the ship by the irresistible and continuous throes of the earth's surface!

Mr. Reed states that the road could be easily extended to take ships of larger size than those at first provided for. The Nicaragua Canal would *present this supreme advantage, that it would be constructed in the outstart to carry larger vessels than any now employed in commerce.*

But Mr. Reed was mistaken in that, as in his other assertions. The sketches I have had made will show this. The grain carrier weighing 2,000 tons would not impose as much pressure on the road-bed per square foot by 40 per cent. as the one of 4,000 tons. The number of rails for the larger vessel would become greater and the spaces between them much less. These additional rails must be supported upon stone walls, concrete or piling, structures resting upon rock or solid ground beneath. When the carriage of the Tokio becomes a question, the number of rails would need to be increased from the original thirteen to twenty-nine, under each of which some kind of substructure must be built. How could this be done while ships are passing over the road? A road which was made at first to bear a possible pressure of, say, 30 tons per square foot, would have to be strengthened to bear one of 100 tons or more, and rails that were 4½ feet apart must be spaced 1⅔ feet apart.

Now we come to the time of passage between San Francisco and New York. For all other trades the Nicaragua route is the more favorable, and were there exactly equal facilities of transit over the two Isthmuses, the southern one, for reasons connected with navigation, would be preferred. Between those two ports the distance in favor of Tehuantepec is about 560 miles. It depends somewhat on the route taken and whether the vessel be propelled by steam or sail. No masters of sailing vessels like the Gulf of Campeachy, with its dangerous northers, or light winds and west-

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erly currents, any more than they like the region of Ventosa Bay, or butting against the Gulf Stream in outward voyages.

The distance in favor of Tehuantepec equals two days' moderate steaming. Mr. McAlpine claims the railroad time would be one hundred and fifty hours. He is a railway engineer, which Mr. Eads is not. Mr. A. Savary also claims that the speed must be a very slow one. To the time on the rails must be added time to lift the ship out of the water and to return it, 30 miles of river, and long detentions at points for passing other vessels. Assuming Mr. McAlpine's rate of speed, the time across, supposing no unusual detention, would be eight or nine days. Mr. Eads claims that he could make 6 miles per hour. Giving his road the benefit of a mean between himself and two railway engineers of distinction, we have 3 miles per hour, or fifty hours on the rails, without including detentions at each siding, which means either a turn-table to change direction so that a ship-car can be run off to one side, or a section of the track constructed as a sub-car to carry its own load, that of the ship-car and ship, off to one side, while another track on wheels is pulled into place to serve the passing ship, after which the ship and car are to be moved back to the road line. Powerful machinery would be required at each of these turn-outs and immensely strong sub-cars. It is clear that once at a station, a ship would be held until the way were clear between it and the next station. Should any accident occur, it matters little how trivial, between these stations, the entire business of the road would be arrested. A ship-car could not be thrown off to one side. Hence, very liberal allowance must be made for meeting the eight to twelve vessels due on the road during the transit of the vessel over the Isthmus. Here, too, the canal presents vast superiority. In it such vessels as Captain Eads proposes to transport would pass each other without a moment's delay.

As the meeting stations along the road would be very costly affairs, there could be but few of them.

Then we have time for—

	Hours.
Road transit	50
Meeting ships	24
River, 30 miles	3
Raising vessel, etc	8
Detentions, etc	8
Total time necessary	93

or about four days.

Estimate for the Nicaragua Canal.

In the Caledonian Canal, exclusive of lakes, 23 miles long, 122 feet wide at surface, and 20 feet deep, steamers of not more than 17 feet draft proceed under steam at 7 to 11 miles, this speed having been made possible by a simple covering of stone on the slopes, which protects them from injury. (See Annual Cyclopedia.) Thus, so long as there are 3 feet under the keel, steamers go about their business. In the Nicaragua Canal of 150 feet width, with such a protection, steamers of 24 feet draft could do the same.

At all events, such craft as Captain Eads is to carry could steam along, or be towed, if sailers, at will. And since we have assumed three times more speed for his railway than railway engineers accord, we will be justified in adopting here what is actually done elsewhere. Thus:

	H.	M.
51¼ miles canal at ten miles per hour	5	15
Twelve locks at twenty-two minutes (double General Weitzel's estimate)	4	24
120 miles river and lake	12	00
Unforeseen detentions	8	00
Total time necessary	29	39

The result is sixty-three hours in favor of the canal, or much more than the time necessary for steamships running via Nicaragua to make good any difference in distance, while, as before stated, currents, winds, and lee shores elsewhere make Nicaragua the best route for sailing craft.

In the Appendix will be found a statement of the course of commerce in respect to the two routes, where it is shown that Nicaragua is the shorter and better one for much the larger portion of the carrying business, and would *have more business* than the ship-railroad could possibly have. No further statement here is regarded as necessary touching this matter.

There is a view of this ship-railway question that appears to me to end all argument. A ship is built to sail in the water; to float upon water; to carry upon water, and to resist strains coming from water. It is a structure owners never take from water support except reluctantly and with apprehension, and always, when it can be done weight is removed before docking. See in Appendix letters of builders, ship-owners, underwriters, and Mr. Savary.

White, in his Manual of Naval Architecture, on page 280 says: "The bottoms of ships crush up or are much damaged, very often before the structural strength against bending strains is overtasked. * * * It appears that, in extreme *cases of support ashore, the maximum bending strains reach from four to six times the maximum strains incidental to the extreme cases of support amongst waves.*" And, treating of transverse strains, on page 283, Mr. White remarks: "It is, however, certain that ships in dock, especially wood-built iron-clad ships, require to be very carefully supported by shores in order to prevent changes in transverse form; and many cases are on record where such changes have actually taken place. The converted iron-clads of the Royal Navy have, for example, been found *to break transversely when in dock even when well shored.*" The vessels here spoken of are relieved of all movable weight before being docked.

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What will owners of our numerous wood-built ships think of the risk, when, to the weight of hull, is added that of cargo, the whole mounted upon wheels and subject to the thrusts and vibrations of an uneven movement over a road?

When vessels are partially water borne, being aground, Mr. White says, page 295: "When a ship grounds, her supports are often so far and small that the bottom cannot withstand the concentrated upward pressure which then produces considerable local damage." Again, page 297: "Grounding is another cause of more or less severe local strains, the intensity depending upon the amount and distribution of the supports. Very *concentrated supports*, as has already been shown, may crush up the bottom."

It thus appears, in Mr. White's view, ships are not calculated for those great *local strains* implied by mechanical contrivances intended to be placed under them, to relieve portions of the carrying car from destructive weights imposed by the changing and irregular surfaces of the road-bed. In short, Mr. White's position is that ships are not intended to touch ground at all, and should they do so, the chances are severe damage as a result. Mr. Reed in his statement before the Senate Committee on Commerce said that Americans could build ships adapted for the railway, and thus have an advantage in its use as compared with other mercantile marines.

In this remark he gave up the whole case; but what are we to do with our fine fleet of wooden ships now employed in the Pacific, and which have no peculiarities of construction called for by the probable exigencies of railway transportation?

The longitudinal strength of ships is considerable, but their weights are so great, especially when loaded, that the strength of hull when out of water is to be counted as nothing. The iron-clad Independencia crushed up when short of her sea-going load by 3,000 tons. The line-of-battle ship Cæsar bent out of line 2 feet when 64 feet of her length hung over the ways. But the Prince of Wales steamer caught upon a wharf edge, her stern being in the water, and lay there a while without a change of form; still, she was mainly water-borne, and, as far as appears, was not loaded. On page 404 Mr. White mentions that a number of iron vessels having broken in two on grounding, the two parts had been floated and reunited successfully. These instances are mentioned because it has been stated that ships may be lifted by the ends or suspended amidships without injury—a most preposterous statement.

The iron plates on a vessel's sides or bottom, when subjected to strains, act upon the rivets precisely like shears with the effect of clipping off the rivets' heads, and this is known as "shearing rivets." Messrs. William Cramp & Sons hauled out upon their "marine ways" a vessel built of steel plates. The shearing process became so active during the descent on the ways back to the water that the vessel sank from loss of rivets.

It is clear the situation calls for a canal, a means of transit for all description of mercantile craft on the ocean, and one that the world will accept as safe, free of peril, and of the taint of experiment and of chances such as the carriage of ships overland would entail.

A canal is free of all experimental character, and the entire feasibility of one across Nicaragua is admitted by all men. What has been said in this paper of the obstacles to be overcome by Captain Eads in his ship-railway project can only be answered by an absolute demonstration in the carriage of ships, and the position taken must stand as unanswerable in any other way than by trial.

Then, should Captain Eads succeed in carrying a ship in apparent safety, he will have simply adopted a means of transit much more costly in the first instance than a canal constructed where the hand of nature has prepared the way, and far more costly to maintain and operate. This would be creating a source of needless and inexcusable tax upon shipping and upon the industry of the Pacific coast people, a tax established by aid of the public treasury and maintained by the Government.

Mr. Reed says on page 44 of Eads's pamphlet: "As regards the comparative economy of transporting a ship's cargo by canal or railway, I am inclined to believe that the railway would prove the more economical of the two." If this means anything, it is that the owners of the Suez Canal should fill up their ditch, lay rails along it to carry ships over on wheels, adding thereby to profits already 90 per cent. of their gross receipts, by saving part of the remaining 10 per cent. paid out for expenses.

[Extracts from the discussion of the Tehuantepec ship-railway scheme before the Committee of Foreign Affairs of the House of Representatives.]

STATEMENT OF MR. CHARLES H. CRAMP.

Mr. KASSON. Please state your residence and occupation.

Mr. CRAMP. I am president of the William Cramp & Sons Ship and Engine Building Company of Philadelphia. We are ship-builders. We have designed and launched over two hundred and fifty vessels that we have built ourselves. We are also the owners of a marine railway and a dry dock, and we have built marine railways. I think we have hauled out the heaviest vessels that have ever been hauled out on temporary ways, one of them a United States monitor with her side armor on and the machinery in her, making a very heavy weight, very much concentrated in a small space. The weight was over 2,200 tons.

Mr. KASSON. Please state now your opinion upon the practicability of adjusting ships, loaded or unloaded, such as are used in commerce, for carriage over a railway, in respect to security.

Mr. CRAMP. It is practically impossible. I have seen, so far, no explanation by the promoters of the scheme of how it can be done. Vessels are so constructed that in docking them, that is, hauling them out on a dry dock or marine

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railway, they must be taken out in such a manner that all the weight, or practically all the weight, remains on the keel. In the dry docks of England and France they are taken out with the entire weight resting on the keel. The weight is so great that when vessels are taken out on the keel, blocks of the hardest oak, Delaware oak 5 feet high, will be settled and pressed together nearly an inch, and I have seen the keel of a vessel sink into these blocks an inch and a half. I am speaking now of empty vessels. The reason we do not take out vessels with the weight resting on any other place than the keel, is because of the settling. If bilge-blocks were pulled under, at the same time that the vessel grounds on the blocks they would make a hole in the vessel; so they are not used anywhere in the world except in the United States, and then only on vessels supported by shores at the sides. After the weight has been taken up they are only supported in the middle.

Mr. KASSON. Be good enough to state where the bilge-blocks are put.

Mr. CRAMP. They are put somewhere outside of the keel, but they are only put under after the entire weight is taken up by the middle. If they were put in beforehand, they would press a hole in the vessel. Very particular directions are given to our men to be careful not to put the blocks in too soon.

Mr. WALKER. The bilge-block is put under, is it not, to keep the vessel from turning over, and not to support it?

Mr. CRAMP. Not to support it. The plates are not made strong enough to give support. If they were made so strong as that, the vessel could not carry any cargo. And in hauling a vessel up on a marine railway it is a little more difficult, because there is a motion of the vessel—a falling over—and you have to be very careful in the use of the bilge-blocks. They must be used, but they have to be used with very great care. We launch so that the keel on the fore part of the vessel shall come out of the water before we begin to pull the forward bilge-blocks under, and in pulling them we take care to let them touch only on one side, so careful are we not to get too much weight on them. I have seen cases where, in the anxiety to do things right, the bilge-blocks were pulled under too soon. In such a case, as the vessel comes up and alters her position, the result is either a hole in the vessel or the breaking of the blocks. I have seen both results myself. I remember a captured blockade runner that was put on the marine railway at Brooklyn, N. Y. When she was put on she did not leak any at all, but after she was taken off she leaked very rapidly, and sank. The reason was that the bilge-blocks bore a little too hard on the plating. They came near a seam, and the steel being thin, the seam canted and started the rivets a little, so that at each rivet there was a little leak, and when she was put overboard she sank. Some ship-owners object to taking vessels out on marine railways at all on account of the strains being too great. In using a marine railway, you know, a cradle is pushed underneath the vessel while she is floating. Those cradles are used for empty vessels, and also for small ones. Small vessels are always stronger than large ones, and can stand more strain. I do not know any marine railway in this country that has ever taken out vessels of more than a thousand tons. I am speaking of empty vessels.

Coming back to the question of the carriage, in order to support an empty vessel to carry her a long distance on land, the timber forming the cradles should be fitted neatly to the vessel from, we will say, light water draught down to the keel, fitted throughout the length of each piece of cradle, and the pieces should be very numerous, about 10 feet apart in the length of the vessel, and should conform to the side of the ship from the load water-line down to the keel. Now, the construction of a cradle like that would be an enormous job, and you would have to get the form of every separate vessel. Each vessel has a distinct and separate history; it is rarely that any two vessels are built exactly alike; so every vessel taken across on this railroad would have to have an independent cradle of her own, and you would soon fill the Isthmus with spare cradles, and it would take all the timber in that country and an army of men to build them.

Then, here is another point. People who come to the Isthmus of course want to go through, and every man wants to be first, and twenty-four hours' delay is a very serious matter, but it would take weeks to make a cradle of that kind for your ship. Then, too, every ship captain would have to carry all the lines of his vessel with him in order to have his cradle made to fit.

Mr. KASSON. How long would it require to take a ship from the water and adjust her in the cradle and start her on her land journey, assuming the cradle timbers to be ready for adjustment when she arrived?

Mr. CRAMP. Well, the damage would be done in taking her out of the water. The cradle must be adjusted before the weight comes on the center part. It is too late to adjust it after she is entirely out of the water, because the vessel is then entirely on the cradle, and the blocks are squeezed together. Before there is much weight on the cradle, then is the time to adjust, and it must be done in the water, because if you raise her out of the water one foot you get a certain number of tons weight on the middle, and if you raise her out of the water two feet you get a certain additional number of tons weight on the middle, and when you take the entire vessel out there is five thousand tons weight on the middle; if it is a light vessel it will have pressed the blocks down an inch and a half, and if it is a loaded one I don't know how far it will have pressed them. The adjusting has got to be done in the water. Now, how are you going to do it? You cannot do it with divers. It would take all the divers that are to be found on both continents, and even if you had them there, a diver, you know, works very slowly under water, and the cost would be enormous. I have seen or heard no explanation of how that adjustment is to be done, and I think I know something about the difficulties of the problem, for I have worked at it with my own hands and have been familiar with such work for thirty-five years.

Mr. KASSON. You can give no estimate, then, of the length of time that would be required to adjust one of these vessels into her cradle safely before she could start?

Mr. CRAMP. No, sir; the thing is impracticable. It would cost half as much as the vessel would be worth. Ship-owners do not make very much money; they have not a large margin of profit, and they do not want to spend

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but a trifle on anything of that kind; they cannot afford to spend even 1 per cent. of the value of the vessel for such a purpose, let alone 25 or 30 per cent.

Mr. DUNNELL. Is there a marine ship-railway in Philadelphia?

Mr. CRAMP. Yes, sir; we have one.

Mr. DUNNELL. What is its length?

Mr. CRAMP. We can take out light vessels 250 feet long and heavy vessels 200 feet long.

Mr. DUNNELL. Do you have any difficulty in taking out vessels on that railway?

Mr. CRAMP. We have great difficulty; as I said before, the weight of the entire vessel has to be sustained in the center, and the rails with which we pull up the vessels are only in the center—the weight of the vessel being in the center, the rails are there.

Mr. DUNNELL. Are there other ship-railways in the world?

Mr. CRAMP. Yes, sir; I have seen them in Scotland and in France. There is also one in New York; but all the ship-railways in the United States are small, and none of those in Europe are very large.

Mr. DUNNELL. Those railways are used in Europe, are they?

Mr. CRAMP. Yes, sir; for taking out light vessels.

Mr. DUNNELL. Do you mean that this ship-railway in Philadelphia is used for transporting vessels, or only for hauling them out of the water?

Mr. CRAMP. Not for transporting vessels; only to haul them out.

Mr. WALKER. You mean a contrivance with an inclined plane to haul vessels out of the water?

Mr. CRAMP. Yes, sir; to haul vessels out, in order to repair them. It is only done, however, with small vessels, and even to them there is some injury. We tried once to haul a loaded vessel up on our marine railway there in Philadelphia, a large schooner that had gone south immediately after the war, and brought up a large quantity of old iron, shot, shell, pieces of cannon, and so on, making something like five or six hundred tons. She came back with all that weight of iron in her, and she got heavily strained in coming north, and it was found that it would be expensive to unload her in the ordinary way, so we undertook to haul her up on our marine railway, the owners taking all risk. When we hauled her out we pinched her pretty lively, and she twisted and strained, and opened her seams, and after we had got her one-third out of the water she came to a weak place in the railway and settled something like ten inches, and stopped, and in trying to pull her out of that place we broke our chains and had to let her overboard. Our next attempt was to take her up light, and in hauling her up this railway I think the bilge went down 5 inches.

The CHAIRMAN. How far do you move vessels forward on your railway?

Mr. CRAMP. About the length of themselves, just enough to get the stern out of the water.

Mr. KASSON. In what you stated a while ago as to ship-railways that you had seen, you did not mean railways for the transportation of ships overland?

Mr. CRAMP. No, sir; only for hauling ships out of the water. I wanted to explain to the committee that all vessels, whether hauled up by railways or on dry docks, are only supported at their center, and that the rails are at or near the middle, so that there is no weight on the outsides. We have here and there a wheel on the outside to support the bilge-blocks, but I have seen them go up and down an inch and a half, and in putting them under the vessel we put them up an inch and a half on one side and let them go close on the other. This shows you how impracticable it is to fit the cradle to the shape of the vessel in hauling her out. In the marine railway bilge-blocks are used rounded in form, and the convex surface of the block on top touches the convex surface of the vessel, touching only at a *point* mathematically speaking. Therefore, if there is any strain at all on that point, in goes the iron, or the wood, if it is a wooden vessel, and if there is an unusual strain it makes a break. So, in hauling up on marine railways you always leave one side or the other clear. For instance, you apply the blocks up tight on one side, and on the other side leave, say, an inch and a half, because, owing to the inequalities of the railway, she will be sure to sway from side to side that much. We never pull the bilge-blocks up on both sides. I say that to show you that the idea is unmechanical and against the experience of people who have to use dry docks, whether marine railways or basin docks. Any person familiar with docking vessels on marine railways and basin docks will tell you that. In large basin docks they have no bilge-blocks at all, on account of the danger, but we use them in our dock at Philadelphia. We should be very glad to have you visit our dock or railway at some time when we are taking a vessel out, and you would find it a very interesting thing; it would enable you to understand the matter better in half an hour than you could from days and months of talk.

Mr. KASSON. Now, having made these explanations, please state as plainly as practicable what would be the effect upon a ship of moving her over 100 miles upon a railway; what would be the dangers and difficulties to be encountered in moving the vessel such a distance in that way, supposing her to have been got on the railway safely at the start?

Mr. CRAMP. Well, if she is perfectly safe on the railway the time she starts (and the great expense has been already incurred of getting her started), there is still danger from inequalities in the railway. If there is the slightest inequality in the road, that portion of the bed or cradle supporting the vessel at that point will receive the greatest pressure and will indent the vessel or break the frames or the plating. Wherever there is an inequality, if she encounters a high place the strain will be on that side or on that one point, even with an empty vessel, and of course in the case of a loaded vessel the difficulty and danger will be exaggerated very much. A vessel of 5,000 tons displacement has sometimes 3,000 tons of cargo in her. We are building two ships now for the Central Pacific Railway to carry, each, 3,000 tons of coal from Oregon to San Francisco, and those vessels can be utilized also for freight or passengers. They will have a capacity of 3,000 tons of grain or coal, and that is more than half the weight of the empty vessel. So that you more than double the risks and dangers when you load your vessel, and the slightest

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inequality will exert a stiffer strain on that part which receives most pressure due to a high or a low place in the railway. We have seen that on our own marine railway. After having driven the piles as far as we could by the usual appliances, we found, in the case of that heavy vessel loaded with iron that I have spoken of, that the railway sank down 10 inches at one place.

Mr. PHELPS. What was the total weight in that case?

Mr. CRAMP. About 1,000 tons. She was a small vessel, and small vessels, you know, stand strains better than large ones; the larger a vessel is the weaker she is.

Mr. PHELPS. And the greater the difficulty in getting the proper center for her support?

Mr. CRAMP. Yes, sir; in getting the support properly distributed. Then vessels differ so much in size, that if some person could devise or invent some patent by which you could adjust a cradle to one vessel, it would not do at all for another vessel. Vessels differ all the way from 1,000 tons up to 10,000 tons displacement, and from 25 feet beam to 40, 45, 50, 52 feet.

Mr. KASSON. And the models differ also?

Mr. CRAMP. Yes; the models vary very much.

ADDITIONAL REMARKS OF MR. S. L. PHELPS.

Mr. S. L. PHELPS next addressed the committee as follows:

Mr. CHAIRMAN AND GENTLEMEN: Captain Eads has been misinformed as to what was said here the other day about his surveys. I did not criticise his surveys. I simply criticised the statement of Mr. Fuertes, and said that he had made a statement which was substantially denied by Garay, Captain Eads's surveyor. I cited the report of the engineers of the Tehuantepec Railroad, showing that they themselves had adopted a grade of 116 feet for the present line of road, intending, should their business become extensive enough to justify it, to change their route, increasing the distance several miles, in order to get as low a grade as 58 feet, though by a very tortuous line. Another map in the same report showed all the known lines of survey on the Isthmus, one of which is the one they adopted having a grade of 116 feet, and another this line having a grade of 58 feet. That was the Barnard survey. There were other surveys involving a distance greater by seventeen miles, one of which had a grade of from 25 to 50 feet per mile, and the other from 25 to 43 feet per mile, but both lines are extremely tortuous and totally unfit for a line of ship-railway. That is the point and the only point I made on that subject.

Mr. EADS. That is what I alluded to.

Mr. PHELPS. I said further that if Mr. Fuertes did know where grades could be got of from 25 to 35 feet, they were in places where a ship-railway could not be constructed or a ship carried, on account of the tortuous character of the line. Now Garay states that he had selected a line which he believed would be the one finally adopted, at least the best one of which he had knowledge, he says—the line as traced and located by our commission.

I asked Mr. McAlpine how it was that the cut was only 312 feet instead of 800 feet, as he had stated, and he said that he stood on the mountain side and that Mr. Garay pointed out a line which he intended to take, and that it went right through a point which Mr. McAlpine then sketched (and he showed me the sketch in his note-book), involving a cut of about 800 feet. That is how he came to make that statement.

As to these air-bags of which Captain Eads speaks, and which were used to lift ships in the Black Sea, they hold a ship very much as water would hold her, all the parts bearing on the bottom of the ship with equal pressure, and there would be no such thing as driving a hole in her when supported in that way; but that is an entirely different thing from sustaining the ship upon small supports. The engineer who did that work in the Black Sea was an American. I don't remember his name at this moment, but he proposed to adopt that plan to take vessels over the bar of the Mississippi, when they were of heavier draught than could pass without such aid, and he said that he was opposed by Captain Eads, who contended that ships could not be lifted out of the water with safety, although these air-bags are the very means it was proposed to adopt there for that purpose.

Admiral AMMEN. That engineer's name was Gowan?

Mr. PHELPS. Yes.

Mr. EADS. Do you say that he said I said it could not be done?

Mr. PHELPS. Yes; that you said the ship would be strained by lifting her in that way.

Mr. EADS. His memory is as bad as McAlpine's.

Mr. PHELPS. In reply to Mr. Reed's statement in regard to the facility with which these particular docks can be used, I am not aware that anybody has questioned the fact that ships may be lifted out of the water, and I certainly would not pretend to dispute it, because it is done; but I see no case cited by Captain Eads, in the testimony which he gave before the Senate committee, in which the ship was fully freighted; from the amount of cargo given in each case, it is very clear that neither of those ships was fully freighted; that is, if he gave the tonnage correctly, but it sometimes suits Mr. Reed's purposes to have ships extremely weak, and at other times it suits him to have them strong. I have here the minutes of a Parliamentary investigation in regard to designs for ships of war, from which I wish to cite some testimony given by Mr. Reed. This investigation originated very largely from the building of vessels of the Audacious class, of which I spoke the other day, and evidence was adduced before that committee that the Audacious herself had broken up on touching bottom in the river Clyde on perfectly smooth water, when the water had left her about 10 inches. Mr. Reed being a witness before the committee was asked this question: "I believe the evidence was to the effect that the Audacious had suffered from taking the ground on a perfectly fair bottom?—

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Answer. My own opinion is that no ship is so fitted for taking the ground without large injury as the Audacious class, and particularly taking the ground in smooth water. I believe that if a ship framed, as is more usual in the merchant service, with one bottom, and that bottom crossed by a number of very stout frames close together, takes the ground at speed, she tears such a frightful hole in herself that she is very much worse off than if she had indented the bottom, so to speak.

"Question. As a matter of fact, in the Clyde, heavily laden merchant ships do take the ground almost every tide?

"Answer. There are repeated instances within my own knowledge of ships built in the ordinary way completely breaking down when taking the ground, as soon as ever they took it. If you have to design a ship for taking the ground, and you know that the service she is going upon involves that, it is no doubt a very proper thing to put iron into her to adapt her for that purpose."

Mr. BLOUNT. Have you any objection to giving your opinion as to Captain Eads's plan of transporting the vessel after he gets her on board his car—as there seems to be no dispute about the possibility of lifting her out of the water?

Mr. PHELPS. There is no dispute about lifting her out of the water, but there is some dispute about lifting her out of the water in such a manner as to make it safe to transport her on this railway. Mr. Cramp stated to you the other day the difficulties of taking a vessel out so as not to injure her. He told you that the keel sank into his oak blocks an inch and a half, and that consequently the weight of the vessel had to come on the oak blocks before they could put any support whatever under the bilge, and that therefore a cradle could not be adjusted under a ship, under water, so as not to have more strain on some points than on others; he said that if she were a loaded ship, the chances were great that she would be badly damaged before she got out of the water at all on a cradle of that kind designed for transporting her on the railway.

Mr. BLOUNT. My inquiry was not as to whether the practicability of transporting vessels safely in this way was or was not proved. Captain Eads has exhibited and explained to us his proposed method of transporting a ship on his car, and I shall be glad if you will give us your view on that subject. Do you believe it is practicable to do what he proposes?

Mr. PHELPS. I do not believe it is practicable to transport a ship on a car at all, for the reason that however well she may be supported in one position, she will not continue to be supported in the same manner when she has been moved 10 feet, because you cannot maintain a plane; you cannot with eight wheels under an ordinary car keep all eight bearing without a system of equalizing bars, or some equivalent device, notwithstanding the fact that your car is pivoted in the center on a truck. In cars constructed with eight wheels it is found impossible to distribute the weight so as to make each of the eight wheels take a portion of it. Now, when you take a ship 400 or 500 feet in length, and 40 or 50 feet in breadth, over a railway-bed you are certain to have inequalities, and while the ship may, when you lift her in the dock, have an equal bearing on all parts of the cradle, you cannot keep the pressure equally distributed. The strain on the ship where the cradle does touch her will necessarily be very great; the cradle at each point where it touches the ship will be supporting an enormous weight, and any change whatever in the plane of the road-bed will bring a destructive weight upon particular points.

Captain Eads has read you a letter from a man who handles canal-boats, and who talks about docking ships because he can lift and dock a canal-boat! Why, a canal-boat is no more like a ship than a drygoods box; indeed, a canal-boat is only a drygoods box. The ordinary canal-boat has only 4 or 5 feet of hold; it has no depth of hold or of cargo. But when you have to deal with a ship with from 20 to 35 feet depth of cargo, you have an entirely different problem, and there can be no comparison between the two cases. You have got a dead rise in the one case, and none in the other, and the two things are no more alike than a cart and a coach.

I gave you the other day some reasons why Sir Edward Reed's opinion as a naval constructor was not regarded as of much weight anywhere now, and I told you of some of the errors into which he has fallen. I did not say anything against him in any other capacity except as a naval constructor. I did cite repeated instances of his entire failure in that capacity. I spoke of the Bessemer channel-steamer, which, after she was launched and about ready for her trial trip, he lauded very highly. He said she was to be the most perfect thing that had ever been afloat, and altogether he was very enthusiastic over her. She came around from the place where she was built to London, and when she was completed she proved to be an entire failure, just as the Lavidia was, for which also Sir Edward Reed was responsible. The Lavidia was an absolute departure from all known methods of ship construction, and she thrashed herself to pieces on her trial trip.

In regard to the grades on Captain Eads's proposed railway line, it was stated here the other day that a locomotive with locked wheels, when the track was wet, had gone down a grade of 125 feet like lightning.

Mr. LORD. One hundred and twenty-five feet in a mile?

Mr. PHELPS. That is my recollection of the grade as stated.

Mr. EADS. Have you got any authority for saying that Sir Edward Reed was responsible for the Lavidia?

Mr. PHELPS. Yes, sir; I have it here in the eighteenth volume of the Transactions of the Institution of Naval Architects, 1877, pages 24 to 29. I read you the other day the statement that Sir Edward Reed made there in regard to that form of ship. He said: "I need hardly say that the circular form possesses both these advantages (carrying capacity and ability to bear thick armor) in the highest degree, because they both result directly from the fact that of all circumferences of given length, the circle is that which embraces the largest area. That some ends of ship-shape character should be given to all sea-going ships at present, for reducing resistance and otherwise improving sea-going qualities, I do not for a moment deny or doubt, but I maintain that there are many reasons why we should, in proposing citadel ships, well consider the circular form as our form of departure, and why we should be carefully on our guard against greatly incumbering the broad and short citadel with ends of much length and fineness."

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Mr. EADS. I wanted to find out if you could tell me how it was that Admiral Popoff was not the designer of the Lavidia?

Mr. PHELPS. He was not.

Mr. EADS. That information is something new; the Lavidia is always spoken of as on the plan of the Popoff iron-clad.

Mr. PHELPS. She was built on that plan, except that she had a bow such as Sir Edward Reed speaks of. She had about 40 feet each of bow and stern.

Mr. EADS. I was in hopes that you were going to read something that would show that the plan of the Lavidia was Sir Edward Reed's.

Mr. PHELPS. No; but I say he is responsible for her. He was the adviser of the Russians in the construction of those circular ships, and he had made a study of that form of vessels, and the views that he expressed covered the exact idea of the Lavidia, and when the Lavidia had put into Ferrol in distress he tried to maintain that she had proved a success after all; but the ship has been broken up, having proved an enormously expensive failure.

Mr. EADS. Where was she broken up?

Mr. PHELPS. In the Black Sea; she put into Ferrol in distress, and by watching for an opportunity was got around into the Black Sea and was broken up, and they have used her iron in the construction of other vessels or as old iron.

Mr. EADS. I know all about the storm that she encountered in the Bay of Biscay which disabled her.

Mr. KASSON. You have only a few minutes of your time left, Captain Phelps.

Mr. PHELPS. I don't know that I care to take up any more of the time of the committee, inasmuch as I have answered all the points that Captain Eads has made here.

Mr. BLOUNT. I should like to have your opinion as to Captain Eads's plan of putting a ship on his railway, as explained by him and illustrated by this cut in the Scientific American.

Mr. PHELPS. [Examining the cut.] The first objection that occurs to me to this plan is that the plan cannot be carried out. Captain Eads tells you that he is going to carry a ship on twelve rails, with 5 tons pressure to each wheel, and the wheels 3 feet apart. Now what is the weight of a three-feet section of a ship? If she is a 4,000-ton ship, it is about 80 tons. Therefore Captain Eads has got to carry 80 tons on three wheels, and that is clearly more than the 5 tons to a wheel upon which he calculates. And he has to carry the car besides. When he has got that weight, whatever it is, upon each wheel he has to be prepared to have the entire weight fall, not upon all the wheels under that ship equally, but on one-tenth, or one-twelfth, or one-fifteenth of them, and if the weight to start with is 10 tons on each wheel, he must be prepared to have a weight of 100 tons or perhaps 150 tons upon some of his wheels according to the changes of pressure which will result from the inequalities of his road-bed. In a time of great storms such as they have down there, his road may go down a foot in some one place, just as Mr. Cramp's marine railway went down when he undertook to haul up that three-masted schooner, the whole weight of which was only 1,000 tons. He told you the other day that although that was the entire weight, yet as a result of the concentration of the weight at one point his railway went down 10 inches.

Mr. BLOUNT. You speak of the weight where there is more pressure than there ought to be; in such a case where is the damage done, to the road or to the vessel, or to both?

Mr. PHELPS. It is done to both, and I will show you how. There is what is called the upward thrust as well as the weight pressure. You have the resistance from a weight acting upwardly. In this connection I will read a passage from Mr. White's Manual of Naval Architecture. He says: "Surplus buoyancy in a ship afloat is not usually found so much concentrated as surplus weight, but in some instances the excess of buoyancy produces a considerable local strain, tending to force the bottom upward. When a ship grounds, her supports are often so few and small that the bottom cannot withstand the concentrated upward pressure, which then produces considerable local damage."

There you have another result which would happen from inequalities in the road-bed.

Mr. LORD. Do you mean to illustrate the idea that while the ship is standing at rest the load would press equally upon all the wheels, but as soon as she moves off and comes to an inequality in the road-bed and is swayed one way or the other, then a large portion of the weight will be taken from one part of the supports and thrown upon another part?

Mr. PHELPS. Precisely.

Mr. LORD. And, as I understand it, you argue that that pressure would vary at every second of time as the ship progressed?

Mr. PHELPS. Yes, sir. On that point I will refer you to the opinion of Mr. P. F. Rowland.

Mr. LORD. Did not Mr. Eads tell us that by his combinations of springs he expected to avoid that difficulty, and to keep the pressure equal under all circumstances?

Mr. PHELPS. How can a spring at one moment not support a ship and at the next moment support it?

Mr. EADS. How can you carry the weight of a two-story brick house 150 feet long, on three points? Of all the absurd statements that are made, this of adding four other wheels and their taking none of the load, is the most absurd. I have stated in this pamphlet that a brick house can be moved several hundred feet without breaking the bricks.

Mr. PHELPS. You know that twelve wheels are put under a railroad car for the purpose of easing the vibrations; four of the wheels on each side carrying the load, and two passing over the inequalities.

Mr. EADS. Excuse me, they are put there for another purpose.

Mr. PHELPS. I ask attention to the letter of Mr. T. F. Rowland, of the Continental Iron Works, shipbuilders. You have in this pamphlet, which I have laid before you, the opinions of every builder of iron ships in the country except Mr. Cramp, and he gave you his testimony here the other day, and all these shipbuilders are opposed to the

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idea of transporting ships by rail. There is not a solitary shipbuilder in this country who has approved it. Mr. Hartt is no shipbuilder; he never built a ship in his life; and as for Mr. Fernald, he is simply a very clever draughtsman, whose appointment was made under curious circumstances.

Mr. EADS. He was the builder of the Arizona and the Alaska.

Mr. PHELPS. He was not their builder. There is something I could say about Mr. Fernald's appointment which would not do credit to him or anybody else. There is a letter here from Mr. Savary, a civil engineer, a man of very large experience. He had charge of the *inclines* of the Morris Canal and of various other works. He gives a great deal of information in regard to docking vessels, and he pronounces Captain Eads's project utterly impracticable. Mr. Savary, Mr. Conness says, is of all engineers of his acquaintance the man in whom he has most confidence. I do not know him, and I do not know Mr. Conness, except that he was once a Senator of the United States.

Commander Gorringe, in the transportation of Cleopatra's Needle, found out what is meant by bodies moving over plains resting on four points. He had the greatest possible difficulty to keep his support under the thing as it moved along, and, although it weighed only 329 tons, it broke pipes six and eight feet under the streets over which it passed.

Mr. BLOUNT. Of what material were those pipes made?

Mr. PHELPS. Some were earth pipes and some were iron, depending on the purposes for which they were used.

Mr. BLOUNT. Those that were broken were of what material?

Mr. PHELPS. I don't know which kind of pipes were broken—some of the street pipes.

Mr. KASSON. How deep under ground were they?

Mr. PHELPS. Six or eight feet. I told you also the other day of the experience at the Georgetown incline. They have found out there what it means to carry a weight of 400 tons on wheels, and they abandoned the use of water to float the boats because their 200 horse-power engine could not manage the weight. Notwithstanding the fact that they had counterbalancing cars of equal weight to go down when the ponton carrying the boat went up, or vice versa, they were stalled repeatedly with their 200 horse-power turbine wheel, because they could not overcome the friction—for that was all they had to do. They have been compelled to reconstruct heir tracks. They had relaid them once when I was there, and they were still laying them over again in portions, because they had not got them true enough, and their flat canal-boats were being strained because of the little inequalities that still existed. And it should be remembered that that ponton moved only at an extremely slow rate as compared with a rate of five or six miles an hour.

Mr. Eads and his counsel having expressed a desire to reply to the argument of Mr. Phelps delivered at the last meeting, the committee, on motion of Mr. Kasson, agreed that Mr. Eads should be allowed one week to file his reply in writing; that if Mr. Phelps should then desire to make any further reply to Mr. Eads, he should be allowed three days within which to file it, and that then the hearing on the subject should be closed.

Adjourned.

LETTER FROM MR. JAMES B. EADS.

WASHINGTON, *April* 14, 1882.

SIR: I beg leave to submit the following reply to the pamphlets and statements submitted to the committee by Captain Phelps.

Captain Phelps asserts that the "proposition to transport ships by rail belongs to three distinct professional pursuits. It embraces the knowledge of the seaman, engineer, and shipbuilder, and in importance in the order named." The statement that a seaman, as such, is authority upon the question involving the scientific principles relating to the practicability of constructing and operating a ship-railway is simply absurd. The captain of a vessel, however well versed in his calling, is likely to know no more of the strains which his vessel is capable of undergoing when upon a dry-dock, or when being transported upon a well-constructed railway, than the conductor upon a train is likely to know of the scientific principles upon which the engine is constructed which hauls his train, or the bridges over which it passes. A seaman may learn, by experience, to know the conditions upon which his vessel is safe or in peril at sea and may be fully competent to secure that safety and avoid that peril, and yet he may be, and generally is, as ignorant of the scientific principles upon which the ship is constructed as is the boy in his cabin.

On the second page of his pamphlet he says: "It is singular to find the readiness of men very able in their professions to express opinions and positive views of things foreign to their experience." Truly, out of his own mouth does he condemn himself. It is not pretended by Captain Phelps that he has ever had experience in building or docking ships, in constructing or operating railways, in digging or operating canals; neither does he pretend to have ever studied or practiced engineering in any of its branches; and yet we find him expressing opinions in the most positive and dogmatical way upon subjects which demand the most thorough knowledge of all these matters.

On the first page of his pamphlet Captain Phelps says that seamen "learn of the perils and dangers lurking in the dock and ways, for all seamen of experience have known of disasters in some form upon cradles."

It is not true that seamen have any such fear, but it is true that hundreds of vessels are docked every week without the slightest injury to them and without any fear that they will be injured.

Mr. William John, the distinguished builder of the City of Rome, says:

"The practice of lifting a ship of large size clean out of the water has become an every-day occurrence."

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Mr. Willam F. Buckley, president of the New York Balanced Dock Company, says:

"We do not refuse any class of ships or steamers, even with their coals and cargoes on board, whose length does not exceed the length of the dock. In every case in which we have taken up steamers with cargo in, it has been done without the least strain or injury to the vessel. As the rule is to make a charge for raising cargo in the vessel, they usually come without cargo."

The highly responsible firm of Emmerson, Murgatroyd & Co. have addressed me the following proposition, in which it will be seen that they offer to take all the risk of lifting loaded vessels on to the railway:

"JAMES B. EADS, Esq., C. E.:

"MY DEAR SIR: When you are ready to commence the construction of your ship-railway, we shall be pleased to undertake the building and completion of the necessary works for placing the ship with her cargo on the railway track, ready for attaching the locomotives to her, and after transport across the Isthmus to lower her safely again until she is afloat. A lifting apparatus will be required at each side of the Isthmus which will lift or lower ships as required. This portion of the work we are fully prepared to execute with the greatest promptness, on the same terms on which we built the hydraulic docks at Bombay and Malta, and the Anderton Canal lift in Cheshire.

"We have no hesitation in guaranteeing the lifting of a fully-loaded ship or steamer of 8,000 or 10,000 tons weight on a railway car from the sea or harbor level to that of your permanent way in thirty minutes, with absolute safety to the ship and the works, where the life is not over fifty feet vertically. We will undertake to construct all the plant and works necessary to do this at each end of your line, and complete everything ready for attaching the locomotive to the car on which the ship is to be lifted and transported; this car, or any number of them, we will furnish also.

"The locomotives or railway construction are not in our line; but if it were a matter of importance to cover, in addition, the construction of the locomotives, turn-tables, &c.. and ten miles of railway, as proposed by you to the United States, we have no doubt we could unite with us some other responsible parties engaged in that kind of works to execute them and guarantee the safe transportation of the loaded ships of the weight mentioned over the railway."

Captain Phelps is "at swords' points" with every one who has the temerity to differ with him. He undertakes to show a contradiction between Professor Fuertes and Señor Garay, as to the grades at Tehuantepec. In this he is, as usual, unsuccessful. Señor Garay surveyed one line, and found on one portion of it, and for a very short distance, two per cent. grades. In his report he says: "The line traced and located by our commission for the present is only a study that may be improved and perhaps even abandoned for a better line if, in subsequent surveys, more favorable ground is found." Professor Fuertes, in the survey he made, found more favorable ground, and so certifies. The charge by Captain Phelps, that the statement made by Professor Fuertes was incorrect, is not justified by the facts.

Captain Phelps prints in an appendix to his pamphlet a number of letters which, in his opinion, settle the question of the impracticability of the ship-railway; among them is a letter of William J. McAlpine. Years ago, when I had commenced the construction of the Saint Louis Bridge, Mr. McAlpine attacked the project and declared my plans impracticable. Notwithstanding his efforts to weaken the public confidence in them, the bridge was built in accordance with those plans, and it now stands a mute witness of the incompetency of Mr. McAlpine as an engineer. He now declares that he examined the line selected by my engineers for the ship-railway. This is absolutely untrue.

Captain Phelps prints an extract from a letter of the Atlantic Works of Boston, as follows: "Our positive ignorance of this matter throughout forbids our expressing any opinion at length." Later on, however, it appears (as per another extract) that Admiral Ammen succeeded in persuading a man who signs himself "Alfred E. Cox, jr.," to attach the name of the "Atlantic Works" to a certificate which the previously expressed ignorance would have hardly justified.

A letter is printed from C. H. Delamater & Co., of the Delamater Iron Works, the value of which is indicated by two sentences which it contains, and which are as follows:

"We feel the subject is one that requires more careful investigation than we have been able to give the subject. * * * We have looked upon the difficulty of building either canal or railroad as so serious as almost to preclude the carrying out of either scheme."

Many of the quotations made by Captain Phelps, both in the body of his pamphlet and in the appendix, are, as will appear upon their face, of absolutely no value. John Roach and Cramp & Sons are about the only shipbuilders whose opinions would be likely to attract any attention. Their opinions have doubtless been given without even a partial understanding of the means proposed to raise the vessel, of the manner of constructing the track and distributing the weight of the vessel and car, and of the many other matters necessary to be known before an opinion could be fairly given. In the matter of these opposing opinions, however, the climax of absurdity is reached when it is sought to overwhelm the ship-railway and settle grave questions of engineering by the opinions of underwriters.

The following statement is found on page 4 of Captain Phelps's pamphlet:

"Captain Eads points especially to the letters of three engineers, Garay, Fuertes, and Williams, and his whole pamphlet in some sense revolves about Mr. Reed, ex-English naval constructor, as the central figure. If the evidence of these men breaks down, the whole fabric tumbles."

This statement is on a par with the many other absurd statements made by Captain Phelps. While the value of the testimony of Sir Edward Reed, Professor Fuertes, and Señor Garay is very great, all that they have said might be entirely disregarded and the practicability of the ship-railway still be most conclusively demonstrated by the testimony of other witnesses. The evidence upon this subject is, in the language of the committee of the Senate, "so overwhelming and conclusive," and the witnesses are men of such great reputation, character, and experience, that Captain Phelps is forced to adopt the pitiable expedient of seeking to mislead the committee into the belief that no other testimony or witnesses exist.

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I call the especial attention of the committee to the testimony printed in the appendix hereto. If this does not establish the practicability of constructing and operating a railway for the transportation of ships, human testimony would seem to be powerless to establish anything. Among the witnesses whose names appear in addition to Sir E. J. Reed are Nathaniel Barnaby, present chief constructor of the British navy; William John, who built the City of Rome, and who was for many years the scientific adviser of the committee of Lloyd's Register of British shipping, London; John Fowler, who was consulting engineer of the Egyptian Government, and who is a past president of the Institute of Engineers in England; George Fosbury Lyster, who has been engineer-in-chief of the Liverpool docks for twenty years; E. Leader Williams, an English civil engineer of high reputation; Clark & Stanfield, designers of hydraulic lift docks; William Pearce, proprietor of one of the largest shipbuilding establishments in Scotland, and who built the Arizona, Elbe, Alaska, and many other large and fine steamers; Lionel B. Wells, engineer in charge of the Anderton Lift in England; Sidengham Duer, an able English engineer of great experience in the docking and handling of ships; B. Baker, who is recognized as one of the ablest engineers in London; Francis Elgar, a naval architect of great experience and ability; Commodore Wilson, chief constructor of the United States Navy; Commodore F. W. Easby, the last chief constructor of the United States Navy; Capt. Edward Hartt and Mr. H. L. Fernald, United States naval constructors; General Q. A. Gillmore and Maj. Charles R. Suter, of the United States Engineers; General G. T. Beauregard, formerly of the United States Engineer Corps; and William Sooy Smith, Henry Flad, C. Shaler Smith, B. M. Harrod, T. C. Clarke, J. J. Williams, E. L. Corthell, A. Dempster, and Max E. Schmidt, all engineers of unquestioned reputation and ability.

In connection with the question of practicability the committee should not lose sight of the fact that I propose to demonstrate the entire practicability of the ship-railway before the Government of the United States becomes in any way liable upon its guarantee. In this connection also I desire to again express to the committee my solemn conviction that the question of the practicability of constructing a harbor at Greytown is one of great gravity. I have devoted much time to, and have had no inconsiderable experience in, hydraulic engineering, and I have moreover examined with some care the problems presented at Greytown. I have no hesitation in placing my opinion distinctly on the record that all the questions involved in the construction of the ship-railway and the transportation of vessels over it, taken together, do not begin to present as grave uncertainties as those involved in the improvement of this harbor. It is scarcely correct to speak of the *harbor* at Greytown, for there is no longer a harbor there. The San Juan River having deserted its old channel, the only means by which a depth of water was maintained ceased to exist, and the harbor, where once the vessels of the Government floated, has become obliterated and closed up by a mass of drifting sands. I do not say that a harbor cannot be constructed at Greytown, for, with sufficient money and time, the engineers of the present day can accomplish almost any work, but if many years of time and many millions of money are to be regarded as factors in the problem, then it may be truly said that the improvement of this harbor is impracticable. If the plan, as laid down on the large map in the committee room be the one proposed to reconstruct the harbor, then I am willing to ignore the questions of time and money, and positively declare that such works as are shown on the plan will never produce the desired results. The advocates of the Nicaragua Canal scheme have studiously avoided submitting to the committee any definite plan for harbor improvement, but have contented themselves with the oft-repeated general assertions of Captains Phelps and Merry, that the work could and would be done. Shall the opinions of such men as these have any weight with the committee upon the practicability of this harbor when no experienced hydraulic engineer has been willing to certify to it? Captain Phelps talks of digging a canal of sufficient capacity to accommodate the commerce of all the future, and Captain Merry draws the picture of 10,000 and 15,000 ton vessels sailing through the canal. Without stopping to notice the absurdity of these statements we may still ask the question, of what value would such a canal be without harbors? The violent attacks made upon the practicability of the ship-railway may have been inspired by the hope that in this way the attention of the committee would be diverted from the serious questions involved in the improvement of Greytown Harbor.

On page 14 of his pamphlet, Captain Phelps says:

"The estimated cost of the Nicaragua Canal, based upon actual instrumental measurements, including lake, river, and harbor work, is $41,000,000."

And yet he and his associates ask the United States Government to give them a guarantee upon $100,000,000. This admission and demand place these gentlemen in anything but an enviable position. They either know that the statement as to the total cost of the work is grossly erroneous, or else they are seeking to secure a government guarantee far in excess of what honest men should demand.

Again, Captain Phelps seems greatly alarmed at the damage which may be done by earthquakes to ships upon the railway. On page 15 of his pamphlet, he says: "While they would probably not injure the road-bed they would destroy any shipping on the road mounted upon cars." How it would be possible for an earthquake to injure a ship upon the railway and yet not injure the road-bed presents a very interesting problem, soluble only by those "accustomed to the perils of the sea." Captain Phelps does not stop to consider the effect which an earthquake would have upon the canal at Nicaragua, a locality where earthquakes are much more likely to occur than at Tehuantepec.

Captain Phelps's statement of the rate of speed at which vessels will be able to move through the canal, and the time of detention at locks, is about as ridiculous as his earthquake statement. The idea of propelling great ocean steamers through a canal at the rate of 10 miles an hour is an idea born only of a disordered brain, and indicates but too surely the total unreliability of the man who conceives it. The average rate of speed of deep-draught vessels passing through the Suez Canal does not exceed two miles per hour, and it may be safely concluded that this rate would not be exceeded at Nicaragua. The locks would also prove a constant source of delay to commerce.

In this connection I would also notice Captain Phelps's effort to correct (?) my figures as to the distance saved in a passage by Tehuantepec over Nicaragua and Panama. My statement of distances was made in statute miles.

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Captain Phelps seeks to induce the belief that it is incorrect by stating the distances in nautical miles, which are about one-sixth longer than statute miles. He carefully avoids explaining this discrepancy, however.

Captain Phelps has stated that no vessel with a full cargo has been taken out upon a dry-dock, and has referred to the list of those docked with cargo on the hydraulic dock at Malta. From the large list furnished by the secretary of that dock company of vessels taken out with cargo on board, I refer to the following:

Name of steamer.	Gross register (tonnage).	Net register (tonnage).	Cargo on board.	Excess of cargo over net register (tons).
Egbert	1,717	1,111	1,600	489
Volmer	1,531	979	1,200	221
Magdala	2,134	1,358	1,700	342
Good Hope	1,555	1,018	1,500	482
James W. Barber	1,443	981	1,140	159
Crimden	1,710	1,100	1,334	234

The gross registered tonnage is ascertained by dividing the entire inclosed area of the ship in cubic feet, including cabins on deck, as well as the entire internal area of the hull, by 100.

The net registered tonnage is ascertained by dividing the internal area of the ship, in cubic feet, by 100; the area occupied by the engines, boilers, coal bunkers, and the like having been first deducted. The net registered tonnage is therefore intended to represent the capacity of the ship as a freight carrier. In one of Captain Phelps's tables he states the *gross tonnage* of the Servia at 8,500 tons, and the "cargo-carrying capacity" at 6,500 tons. It will be seen that each one of these six vessels was fully loaded, the actual cargo on board being largely in excess of the net registered tonnage. The above is an absolute refutation of the misstatement made by Captain Phelps.

In addition to this I may again refer to the letter, dated February 14, from Mr. William F. Buckley, president of the New York Balanced Dock Company, giving a list of vessels taken out on his dock with cargoes in them:

Ship Great Victoria, 2,386 tons.
Ship Triumphant, 2,046 tons.
Ship America, 2,054 tons.
Ship Hagerstown, 1,903 tons.
Ship S. C. Blanchard, 1,903 tons.
Steamer Colorado, 2,765 tons.
Steamer Rio Grande, 2,565 tons.
Steamer Thingvalla, 2,436 tons.
Steamer Monarch, 2,366 tons.
Steamer Lepanto, 2,310 tons.
Steamer State of Nevada, 2,488 tons.

Mr. Buckley, in his letter, says: "We do not refuse any class of ships or steamers, even with their coals and cargoes on board, whose length does not exceed the length of the dock."

Captain Phelps strives to create the belief that the ship-railway will be able to transport vessels which weigh only 4,000 tons, with their cargoes in them. This is unwarranted by the facts. The road-beds of all railways are more substantial and solid a year or two after construction than when first built, and to sustain a test of 4,000 tons immediately after completion would require a road-bed able to sustain, a year later, with equal safety, 6,000 or 7,000 tons. The test of 4,000 tons will require a roadway capable of transporting vessels of at least 6,000 tons gross weight, and this would include upwards of ninety-five per cent. of the aggregate tonnage of all the vessels contained in Lloyds' Register of British Shipping for 1881. This includes the names of 15,492 vessels, with an aggregate tonnage of 10,528,625 tons. A steamer of 2,600 tons gross register would weigh, with full cargo and coals, about 4,000 tons; and in the entire register there are only 1,030,779 tons, or ten per cent. of this amount, in vessels of greater tonnage than the proposed test. That is to say, if the railway was only capable of transporting ships weighing, when loaded, 4,000 tons, it would accommodate ninety per cent. of the tonnage of the world. But as it will be built at once for vessels weighing 6,000 tons, it will accommodate at least ninety-five per cent. of the world's tonnage.

Again, Captain Phelps says: "There are a great many men in this country, and very able men, engaged in the construction of iron vessels, but they to a man oppose the idea of ship transportation by rail, as do also all engaged in their construction of wood. The names of two naval constructors appear in the list. One of these men is a ship-carpenter, and in no sense a builder of ships; the other is a draftsman, and a very good one."

This statement is full of errors. One of the United States naval constructors referred to so disrespectfully (Capt. Edward Hartt) has no superior as a practical and scientific shipbuilder in this country. He is one of the oldest constructors in the Navy. His father was the first chief constructor in the Navy, and his grandfather was the builder of the United States war vessels the Constitution and United States, that are referred to with such pride by all Americans. Captain Phelps has been a seaman long enough to know that naval constructors in the American and British navies are required to serve a regular apprenticeship as ship-carpenters, and are therefore thoroughly versed in the practical part of their profession. They also have to acquire a full scientific knowledge of the principles

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involved in shipbuilding by a system of mental training and investigation, to which Captain Phelps is evidently a total stranger. Some of the ablest mathematicians of the world have devoted many years of their lives to this department, and in this way shipbuilding has advanced from the category of mechanical art and is now recognized as a science.

Particular attention is called to the letter of Commodore T. D. Wilson, the present chief constructor of the United States Navy, which will be found in the appendix. In this letter Commodore Wilson says:

"I see no good reason why any vessel cannot be successfully raised and transported upon a properly constructed railway with the grades as stated, when reasonable skill and care are used in the work, and I believe that the strains she will be subjected to will be inferior to those to which ocean steamers are constantly exposed."

The practicability of the ship-railway is therefore indorsed, not only by the chief constructor of the British Navy, but by the chief constructor of the American Navy also; and the value of these indorsements is apparent when it is remembered that they emanate from men chosen from among all others as eminently qualified to hold such high and responsible positions. As these indorsements, however, are adverse to the views and interests of Captain Phelps, he will doubtless entertain very little respect for their authors.

But Captain Phelps does not content himself with simply making silly and absurd statements in favor of the canal and against the ship-railway. He assails Sir Edward Reed in a most unjust way, and seeks to injure him in the opinion of the committee. It is very easy to understand the motive of this attack. Some time ago Captain Phelps issued a pamphlet and distributed it among Senators and members of the House, in which he gave expression to his peculiar views on the subject of the canal and ship-railway. The statements made in that pamphlet had, for absurdity, never been equaled up to that time, and have only been excelled by his more recent production. It happened that Admiral Ammen thought it necessary to do that which Captain Phelps so much condemns in me, viz, seek for information outside the boundaries of his own country, and well knowing the fact that Sir Edward Reed occupied the very highest position as an engineer and naval constructor, addressed him a letter calling his attention to my proposed ship-railway and to his proposed canal, and solicited from him an expression of his views. The fact that Admiral Ammen selected Sir Edward from among all other engineers in England is very significant, and shows that he must have held him in the highest regard. There was no talk then about Sir Edward being an "ex-naval constructor out of employment," no suggestion that by reason of many failures he was "unsafe and unreliable to follow." Admiral Ammen, not content with merely writing a letter, in an evil hour yielded to temptation and forwarded to Sir Edward one of the pamphlets of Captain Phelps. He seemed to regard Captain Phelps in much the same light as that in which the famous Captain Edward Cuttle was wont to regard his ancient friend Jack Bunsby, and no doubt indulged in the fond hope that the "chunks of wisdom" contained in the Bunsby pamphlet would compel Sir Edward to denounce the ship-railway as impracticable. The result proved, however, that the pamphlet had just an opposite effect from that expected. If Sir Edward could have by chance entertained any previous doubt upon the subject of the ship-railway the pamphlet would have removed that doubt. In his reply to Admiral Ammen, Sir Edward reviewed the statements of Captain Phelps in detail, and so conclusively demonstrated the absurdity of them that their author became a subject of real commiseration.

The result of all this was that Admiral Ammen and Captain Phelps became offended at Sir Edward, and they now seek to belittle and traduce him. I emphatically deny the truth of any and all statements made orally by Captain Phelps or contained in his pamphlet derogatory to Sir Edward, or which connect him with any failure in his profession. It is a very easy thing for Captain Phelps to make sweeping allegations, but I deny their truth and call upon him to produce the record. Garbled extracts from the record, or mere citation of volume and page, will not do. He has had the temerity to assail one of the most distinguished engineers now living, when the latter is beyond the sea, and he should be prepared to sustain his charges by full and conclusive record proof.

Captain Phelps refers to Sir Edward's connection with the Lavidia and the channel steamer Bessemer, and cites the "Transactions of the Institute of Naval Architects," to show that the alleged failure of these vessels was due to Sir Edward. I have carefully examined the record referred to and find nothing there to justify such an imputation. Admiral Popoff acting for the Russian Government, and Mr. Bessemer, acting for himself, sought the aid of Sir Edward in putting to the test their own peculiar ideas. The "Transactions" cited by Captain Phelps contain the highest encomiums upon the ability and ingenuity with which the designs of these inventors were incorporated in the construction of the vessels.

No living engineer occupies a higher position than does Sir Edward Reed. When he voluntarily retired from the position of chief constructor of the British Navy he was knighted by his sovereign, his successor was appointed upon his recommendation, and the English Parliament (of which he is now an honored member) so highly appreciated the services which he had rendered to the Government that they voted him $25,000. Throughout the civilized world his name is known and honored, and the puny efforts of Captain Phelps to tarnish it can only meet with ignominious failure.

Captain Phelps seeks to convey the impression that I *employed* Sir Edward Reed to advocate the ship-railway project. On page 4 of his pamphlet he says:

"Compelled to go to England to find a ship constructor willing to approve his plans, Captain Eads, rather unfortunately for himself, struck upon Mr. Reed, ex-naval constructor, out of employment."

In reply to this I have only to say that it is absolutely untrue, 1st, that I was compelled to go to England to find a ship constructor willing to approve my plans; and, 2d, that I secured the services of Sir Edward Reed. The letters published in the appendix show the falsity of the first charge, and the high position and character of Sir Edward sufficiently refute the apparent insinuation that he has sold his opinions.

Again Captain Phelps, referring to Sir Edward, says:

"Having since come to this country, he has been going about with Captain Eads, to talk up the ship-railway.

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This statement is also untrue. Sir Edward did not go about with me all during his recent visit. He came to this country to attend to some very important personal interests which he had in Florida. He was in Washington for only a few days, and that was the only time I saw him during his entire visit. He appeared before the Senate committee at its request.

The reasons why a ship-railway is preferable to a canal are numerous and unanswerable. They may be summed up as follows:

1st. The railway can be constructed in four years; it will require from ten to fifteen years to complete the canal;

2d. The railway can be constructed for one-half of the cost of the canal, and can be maintained and operated much more cheaply;

3d. Vessels can be transported by rail much more quickly than by canal;

4th. In case of accident the railway can be repaired more speedily and at less expense than the canal; and,

5th. The railway can be readily made to meet the demands of future commerce, while it is impracticable to enlarge the canal.

It is virtually conceded by the advocates of the Nicaragua scheme that if a canal were practicable at Tehuantepec that would be the preferable route. It being shown that a ship-railway is practicable, it follows that Tehuantepec should be selected, even although the railway possessed no advantage over the canal.

The promoters of the Nicaragua scheme state that the cost of the Saint Louis bridge greatly exceeded my estimates, and that it cost $15,250,000. Professor Woodward's history of the bridge shows that the cost of it was $6,536,729.99. He had access to every document relating to its cost, and states it correctly. It will be seen in the appendix, by the letter of Colonel Flad, the chief assistant engineer of the bridge, and who is now president of the board of public works of Saint Louis, that this is only the revival of an effort made seven years ago to defeat the jetty bill. In this connection I will refer to the fact that the cost of improving the mouth of the Mississippi was undertaken by me for ninety thousand dollars less than the estimate of the distinguished commission of engineers to which the subject was referred in 1875, and that that work is completed, its debts paid, and *one million* of the estimated cost of it is left in the hands of the Government as security for the maintenance for twenty years of the specified maximum channel through the jetties.

Captain Phelps and his associates belong to a class of persons who are opposed to progress and advancement. Were our people all like them the steamship, the telegraph, and the railway car would be unknown. This class has always existed and probably always will exist, and it may be expected that every proposition looking to the abandonment of old methods for new and better ones will meet with their determined opposition. Years ago when it was proposed to apply steam to ocean vessels the country rang with an outcry against it. The proposal was denounced as visionary and absurd, and found its most bitter opponents among that class to which Captain Phelps belongs, namely, seamen. Ship captains without number could then be found ready with the most conclusive reasons why the sail should not be made to give place to steam, and many were the prophecies of dire destruction to life and property which would follow the adoption of so mad a proposal. When it was proposed to connect the Old and the New World by the Atlantic cable the obstructionists laughed at the idea. The cable would break; it could not be made strong enough to sustain its weight; the salt water would affect the material of which it was composed. This and much more they said. Now mighty steamships safely plow the waters of every sea, and the cable has obliterated the distance between the continents. Along the path of human progress, ignorance and prejudice are always retarding the onward march of improvement, and no great enterprise designed to bless the human family has ever attained success without having met and conquered such enemies. It is not, therefore, to be wondered at that when it is proposed to abandon the antiquated canal system, and carry ships overland upon the railway, such men as Captain Phelps, Captain Merry, and Admiral Ammen should, with much clamor and long lists of reasons, raise the issue of impracticability, and make themselves hoarse with the cry of failure. Nor is it strange that many underwriters, proprietors of iron works, and some ship-builders can be found to join in the cry. But men who have devoted their lives to mechanical science, and who have by experience and success attained the highest rank among their fellows, with one voice unite in the assertion that the ship-railway is entirely practicable.

The question is not whether a ship-railway shall be built, for that is even now settled in the affirmative. The only question is, shall it be made an American enterprise, designed to benefit American commerce, or shall its success be due to English capital and for the advantage of English commerce?

Respectfully,

JAMES B. EADS.

Hon. C. G. WILLIAMS, *Chairman of the Committee on Foreign Affairs, of the House of Representatives.*

LETTER FROM MR. S. L. PHELPS.

SIR: The paper Captain Eads has submitted as a reply to my statements in regard to his ship-railway scheme made to the Committee on Foreign Affairs, I can hardly view as in any degree an answer.

I had taken pains to prepare a connected argument, offering reasons and deductions based upon the statements and experience of seamen, ship-builders, railway and other engineers, underwriters and owners, and upon works of acknowledged authority. When before you I produced the publications from which I quoted.

There is hardly an assertion made throughout my statements in respect to the ship-railway that is dependent in any degree upon my own knowledge.

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Captain Eads has not attempted to answer a single mechanical point advanced by me, but has indulged in what may best be classed as a tirade in which unsustained declarations are interwoven.

When I point to the noted failures, as a naval constructor, of Mr. Reed, who is chiefly quoted as an authority by both Captain Eads and in the report of the Committee on Commerce of the Senate, and produce my authorities, Captain Eads makes no attempt to disprove them, but asks you to regard Mr. Reed's reputation as a sufficient refutation. We say that confidence in his judgment was impaired by his innate disposition to seize upon novel, untried, and experimental ventures, giving repeated instances of the utter failure of trials of this character upon which he had entered as an enthusiastic supporter.

His failures as a ship constructor were referred to as indicating want of that precision and scentific exactness to which he lays such high degrees of claim. These were thought sufficient proofs of the unreliable character of opinions he might express in regard to the feasibility of the ship-railway project. I may remark that his statement before the Senate committee bears evidence throughout of the advocate and not of the disinterested witness. His disregard of facts and his erroneous conclusions were indicated by me, but Captain Eads does not attempt to refute my statements in these respects. In one sole particular I owe Mr. Reed the amend, having mistaken his unusual way of expressing tonnage when stating that ships named by him as having been docked with cargo in were not fully loaded. By reference to Lloyd's Register I find they were freighted. As mention was made of the "Captain," and it was intimated that its loss had been charged against Mr. Reed, I can only say if so it is not just, because he gave warning that want of free board would make the vessel dangerous, a criticism entirely sustained in the disaster that followed.

So in the case of Mr. Fuertes, I stated that he, being an engineer, knew that a ship-railway must be in straight lines, and consequently could not follow the tortuous course, embracing 17 miles increased distance, necessary to gain easy grades in passing over the heights, in which are precipitous peaks of 1,000 to 2,000 feet altitude, and I produced the surveys of General Barnard and of Commodore Shufeldt, as well as those of the present Tehuantepec Interocean Railway Company. I quoted Mr. Garay to show that he had no hope of a grade of less than two per cent., or of 105.6 feet per mile, or of a cut less than 312 feet depth—a cut that will require more time to make than is necessary to complete the Nicaragua canal. I might have quoted the ridiculous part of Mr. Fuertes' letter, but the purpose was to expose his subterfuge in his statement respecting the grades obtainable.

I cited the written opinions of every iron-ship builder in this country, and of other ship-builders, as well as that of Mr. Lundorg, a Swedish constructor of European reputation, to show that taking vessels out of water loaded is esteemed by builders as a dangerous operation.

Then I quoted from a number of owners of vessels and managers of large steamship companies to show their concurrence with the builders in this view. I might have quoted Mr. William Guion, amongst whose ships are the City of Rome and the City of Berlin, who only last week told me they regarded docking steamers with cargo in as very unsafe, and only to be done under unavoidable necessity.

In reply, Mr. Eads quotes dock managers and owners. We offer the evidence of dock owners and managers, also, who take our view of the risk undergone.

He gives a long list of experts, as he styles them, who support his railway scheme, but a careful sifting will show that the letters relate largely to lifting ships or to docking them.

The *possibility* of transportation of ships by rail is in some instances regarded favorably, but conditioned upon the road-bed being firm, straight, and of light grade, and the ships to be carried small ones, such as are those of 4,000 tons displacement or less.

Mr. Pearce, one of Captain Eads's authorities, said recently when in New York that he thought "a new iron vessel of not over 4,000 tons displacement might stand the strains *if the road were firm enough*."

Mr. John's statement contains little to give comfort to Mr. Eads; but the committee in reading the various letters will observe that no writer of them attempts to estimate the cost of constructing or of operating a ship-railway, while the character of roadway thought necessary to admit of success in the carriage of a ship is the one requirement in the problem the most costly, difficult, and uncertain to be dealt with.

Captain Eads does not attempt to refute my statement as to the enormous pressure per square foot, imposed by moving bodies, to which the roadway would be subjected, a pressure liable to be 100 or 200 tons, or still more, per square foot, and one so far beyond the experience of engineers in any work ever yet constructed that no one is prepared to say what construction would or could endure it. Then, is Captain Eads prepared with approved plans for bridges over the Coachapa, Chalchijalpa, Coatzacoalcos, Perico, and other rivers and numerous streams he must pass, all subject to floods of great volume in the rainy seasons; streams that overflow their banks and cover wide districts? These bridges must bear the stress of 5,000, 10,000, or even more than 15,000 tons, if a large class of vessels be carried; weights in motion, and massed in lengths ranging from 200 to 500 feet, and in widths of 30 to 50 feet. These weights represent that of 250 to 750 or more of loaded freight cars, placed in the spaces indicated, and moving over the bridge.

He says I misrepresent his differences in distances; that when he gave the difference between New Orleans and San Francisco via Tehuantepec and via Panama as 2,200 miles I knew he meant statute miles. I knew nothing of the kind; but the Hydrographic Office makes the difference to be 1,603 miles, equivalent to 1,789 statute miles, and not nearly 2,200 such miles.

Projects of the most chimerical character have been or are being agitated the world over, each one, however improbable, being demonstrated scientifically as perfectly feasible and sustained by favorable opinions expressed by engineers. The Honduras ship-railway scheme became the subject of wide discussion in English papers: pamphlets upon pamphlets were issued with no end of engineering indorsements; but the scheme ended in miserable disgrace and failure, as have so many others of like description. The periodicals in England are now publishing demonstra-

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tions that the only method of reaching the North Pole is by balloon. How many times have thousands of disappointed people assembled to witness attempts at aerial navigation, demonstrated "by lifetime mechanical scientists" to be of easy execution? Subaqueous navigation has been seriously proposed. Cabins pivoted so as to remain without motion in the heaviest seaway have found men foolish enough to invest their money. A Russian admiral demonstrated that tubs of enormous diameter were to replace vessels of other forms in naval warfare, and Mr. Reed lent himself to that as to the other delusion. The Keely motor is another illustration of scientific pretense, and recently we were here favored with demonstrations, backed by opinions of distinguished technical men, of a newly discovered source of power destined to supplant steam. Ericsson, a truly mechanical scientist, proved long ago that the caloric engine was also to displace the use of steam as a motor.

Ever since philosophers began the search for the fountain of youth, visionary schemes have risen one upon the other, each in turn to be consigned to merited oblivion, but not always without misfortune to credulous dupes.

Da Vinci proved centuries since the efficiency of canal locks, thus solving the only problem there ever was in a canal construction like the one Captain Eads told you would be made across Florida as an auxiliary to his railway. The measurement of heights to be overcome, of the amount of water obtainable, the facility for drainage, and the excavation necessary, are really the only points requiring investigation to demonstrate the feasibility of a proposed canal construction.

The Committee on Commerce of the House of Representatives has recently, according to Captain Eads's philosophy, shown itself "opposed to progress and advancement" by reporting a bill to provide for construction of the Delaware and Chesapeake ship-canal, having two locks. Why does not Captain Eads seize the opportunity to construct and operate a ship-railway in lieu of this proposed canal, thus saving money to the Government and securing profit to himself?

The people of this country very generally are, apparently, "opposed to progress and advancement" and trust still to "antiquated methods," as Congress is being importuned from every section to construct artificial water communications in the interest of cheap carriage. Canal inclines have been in use many years, yet the substitution of rails for the carriage of canal boats has not followed; but, on the contrary, many millions have been expended in canals and in their enlargement. The Canadians have been so stupid as to spend a great sum recently in the enlargement of the Welland Canal. Indeed, the whole world just now is opposed to Mr. Eads's scientific progressive views, notably France, where canal constructions, extensions, and enlargements are popular.

In respect to earthquakes (page 6) Captain Eads quotes me. Any fair-minded reader will at once detect how the captain seems willfully to have misunderstood what I stated of the effects of earthquakes. It is a structure resting upon the earth's surface that is thrown about and destroyed. An entire town may be wrecked and no sign of the commotion that did the mischief be visible in the ground itself. Miners are sometimes unaware of earthquake disturbances above them. The cellars and substructures of buildings are not injured when the buildings themselves tumble to the ground. It is easy to see that ships upon cars would be like buildings resting on the earth's surface, or animals standing, and would be liable to be thrown down as are buildings and animals, while the bed of the road, like the earth's surface, of which it in fact would be part, would be uninjured, except the damage coming of the wrecked car and ship. There would be this difference, however, that a shock which might not injure the low, thick, but yielding walls of the adobe house would destroy a ship resting upon so insecure a foundation as the wheels of a car, leaving both ship and car a mass of scrap-iron.

As Captain Eads has seen fit to reflect upon Mr. McAlpine's evidence by referring to their difference of opinion about the Saint Louis bridge, I think it just to quote from General Warren's report (page 1028) on bridging the Mississippi River. Referring to the Saint Louis bridge:

"The opinions of engineers generally are unfavorable to this form of bridge.

"1. It is a form that interferes too much with navigation. (Report of Army Engineer Board.)

"2. It is not considered a good pattern for economy.

"3. It is subject to great strains, due to temperature.

"4. It is difficult to calculate the strains upon different parts and apportion the dimensions of parts."

The second, third, and fourth reasons were taken from the discussion in the American Society of Civil Engineers.

It thus appears engineers generally concur with McAlpine's views, and we may feel sure those who sunk millions in the bridge concur to a man. That his reputation has not suffered is proven by the frequency of his employment in the greatest of public works, and by his selection, as the civil engineer of the widest reputation of all Americans, by the Austrian Government as a member of an international commission to investigate the question of improvement of the Danube.

When an attorney (?) cannot successfully attack evidence he generally attacks the man who gave it, a truism that applies to the entire paper of Captain Eads, but especially to his unwarranted attack on McAlpine (page 3), in stating that the declaration of that gentleman, "that he had examined personally the route of the ship-railway," is false. Mr. McAlpine was on the Isthmus, and Mr. Eads was not there at the time. How can he know what McAlpine did while there? Mr. Eads told you he himself had made no personal examination of the proposed line of the road.

Captain Eads includes Captain Merry in his criticisms. Is it possible Mr. Merry has so greatly deteriorated as a man of judgment and value since Eads proposed that he should join him in the railway scheme and reap a large share in its profits? He might as well say that Cramp, Roach, McKay, Rowland, Mallory, Webb, Lundorg, Henderson, Cox, Savary, Parker, Hutton, Sir John Hawkshaw, General Weitzel, General Humphreys, General Ammen, the Pusey-Jones Company, the Delemater Company, Lavaller, Cotard, and many others of fame in their pursuits, are dafts and know-nothings.

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On page 931 of the report of General Warren, before referred to, is the following statement:

"The building of the bridge at Saint Louis, giving a headway of only 50 feet at ordinary extreme high water, has compelled a change in the boats running above," etc.

Captain Eads's plans originally embraced a truss bridge, which would have given an equal clearance throughout between piers, and not been subject to the great objection that a steamer must be run through the center of an arch of the existing span to be safe. Much deviation to either side would sweep away all upper works of a boat, since high water reaches to the spring of the arches.

I have always understood that Captain Eads changed the plan of the bridge in the interest of Saint Louis, expecting that it would practically make of that city the head of navigation for all steamers running upon the river below.

As regards the harbor of Greytown, I repeat what was before stated, that the committee of engineers of the Paris canal congress, amongst whom were Lavaller and Cotard, approved Mr. Menocal's plans for reclamation of that harbor; that the American Society of Civil Engineers favorably discussed it; that Mr. Davidson, of the United States Coast Survey, approved it, as had other persons of eminence. General Humphreys observed no difficulty about that point when reporting that the Nicaragua route was preferable to any other surveyed route over the American Isthmus for a ship-canal.

I quoted from the report of the Suez Canal Company for 1880, that the average *running* time of vessels in its canal had been 17 hours and 10 minutes. As the distance is over 100 miles, the *average rate* of speed while *under way* is therefore *about 6 miles per hour.* The total *average time* in making the transit of the canal is 41 *hours;* so that the *average speed made, including laying by at night* and other detentions, is 2½ *miles per hour.*

These figures differ entirely from Captain Eads's unsupported statement on page 6 of his reply.

How does Captain Eads, in his statement that he only saw Mr. Reed in Washington during his recent visit to this country (on page 11 of his reply), account for their visit to General Grant in New York?

On page 11 Captain Eads gives five reasons why the railway would be preferable to a ship-canal. If these reasons are good and valid, and the *science* of the world sustains them, why does not he come down in his demands upon the Government to the same basis of conditions found in the Nicaragua Canal bill? That is to say, ask that when he shall have completed the ship-railway and is actually engaged in carrying any and all vessels offering for transport over the Isthmus, and has carried one, say, of the size of the Pacific Mail Company's steamers now in the Pacific of only 9,000 tons displacement—all done to the satisfaction of owners—then the Government shall guarantee net receipts of 3 per cent., allowing $1,000,000 for expenses of operating and maintaining the road? Instead of this simple, straightforward, and perfectly intelligible petition, made by the canal promoters, Captain Eads has prepared an elaborate system of consecutive trials of small sections, involving twenty-two visits by an inspecting board to the Isthmus, after each one of which, if the trials are reported as conforming to requirements in the letter of the law, he is to have issued to him certain millions of 6 per cent. guaranteed stock. No doubt the possession of such stock, carrying 6 per cent. interest for twenty years, would be very handy for use in securing the money required to proceed with the work. It will be observed, however, that the credit of the Government is the reliance for obtaining money to carry on the work of experiment.

Captain Eads finds no capital ready to venture the road construction. It is the United States Treasury that is to try the experiments and to prove the correctness of the *five reasons* referred to.

As, on page 12, Captain Eads goes into the cost of the Saint Louis bridge, I may be pardoned another reference to that needlessly costly construction, by directing you to the report of the engineer in chief of the Illinois and Saint Louis Bridge Company, Saint Louis, May, 1868, signed "James B. Eads," in which the estimated cost of the bridge, approaches, tunnel, railroad, and land condemnations is given as $4,496,953.09; also to a report of a committee of stockholders, appointed for the purpose of inquiry into its financial condition, February 3, 1875. From this report it is learned that the actual outlays up to October 1, 1874, for the purposes above cited, had been $15,212,598.44. I find no better sources of information in regard to the *actual cost* of this immensely expensive and obstructive structure than that above quoted, being the certificates of the men who furnished the money to build it. Other bridges over the Mississippi, equally efficient, have not cost one-fifth part of the money.

On the same page Captain Eads ventures the statement that seamen opposed the introduction of steam for sea-going vessels. My recollection is that Mr. Dionysius Lardner, a well-known scientist, "who had devoted a life-time to mechanical science," demonstrated *scientifically* that a steamer could not possibly traverse the Atlantic. The men who *proved it could be done, by doing it, were seamen.* Captain Eads says we would oppose ocean telegraph lines, being innovations. I took part in laying the first telegraph cable, and do not recall that seamen engaged in it ridiculed the possibility of both laying and of successfully using such cables. I think we were rather enthusiastic about the undertaking.

The committee will pardon one more quotation from and reference to Mr. Eads's paper, because of the spirit in which it was written, found on the last page, as follows:

"But men who have devoted their lives to mechanical science, and who have by experience and success attained the highest rank among their fellows, with one voice unite in the assertion that the ship-railway is entirely practicable."

This is so well disproved by facts in possession of the committee that I might have left it unheeded, but I cannot forbear rebuking an assertion so presumptuous, so audacious, nor can I forget that Captain Eads was in early life a steamboatman on the Mississippi; that he is understood to have managed glass-works in Saint Louis; that he managed a wrecking company on the Mississippi; that he undertook the management of a life insurance company; that he got into the management of the State Bank of Missouri. The fate of each of these institutions is a matter

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of history. (See sketch by Joseph Brown, esq., Saint Louis.) How these various pursuits comport with a "life devoted to mechanical science" I leave to you to determine. I have made no claims to science, nor have I urged an engineering experience, but I may be allowed to mention that I was engaged for years, under orders of this Government, in making and reducing astronomical observations in this country and South America, being so engaged at about the time, so far as I can judge, that Captain Eads was working the wrecking company. In that long experience I learned to distinguish clearly between real and spurious science.

We have now, for the first time since they were put down, an opportunity to witness the effects of protracted floods upon the Mississippi jetties. As the floods subside how many and how extensive bars will be discovered to have been formed across their line?

Admitting everything Captain Eads claims for his railway, it cannot stand for a moment as a business proposition in a comparison with the canal project.

The expenses of the Suez Canal Company are now 8.85 per cent. of its gross receipts, and might, by regulating the Paris office, be reduced to less than 7 per cent., while the ratio of expense is diminishing in almost the same ratio as the receipts increase, since the cost of operating the canal does not grow with the augmented business. This rate of expenditure embraces a large amount of dredging yearly.

Captain Eads asks that 50 per cent. of gross receipts be allowed for maintenance, management, and conduct of the railway, a proportion less than is realized by any railroad in this country.

The difference in the charges necessary for the road and canal for account of expenses would amount to millions annually and would become a burden upon commerce. Such a comparison made with the Suez Canal Company's expenditures for 1881, being the difference between 50 per cent. and 8.85 per cent. of its receipts, would have amounted to $4,073,275. This simple statement should set at rest all questions respecting the relative merits of the two projects. It is unnecessary to argue regarding the possibility of ship railway transportation. Granting it can be done, the cost of maintaining and operating the railway condemns the project.

The canal route is but 53 miles in length, and lies along a line of water communication in such manner that men and supplies can be placed at any point with ease and facility, and work may be carried on simultaneously at as many places as is desired. The railway line is said to be 150 miles long—not located, we are told—and possesses no such advantage in transportation as the canal line. The heavy work of the mountain region must be done under every disadvantage, and will require consequently much greater length of time in proportion to quantities of excavation to be done than would the same work along the accessible canal route. The amount of work for the railway, then, would be greater, and the time required to accomplish it would be in still greater ratio.

United States engineers have placed the estimated cost of the entire canal and harbor work at $41,000,000.

The canal society claims that the additions for contingencies, interest during construction, commissions, Nicaragua's shares, &c., will swell the total actual cost to $75,000,000, but that capitalists will require more latitude than that limit gives, and hence $100,000,000 is fixed upon as the greatest amount of stock that can be issued. The United States are to have a representative in the board of direction, and will thus have a voice in all the company'

Captain Eads estimates the cost of his railway at $75,000,000. What he includes he has not stated so far as I have learned, and as surveys of much of the route have not been made, it is difficult to understand on what he bases estimates for cost. But admitting the correctness of them, on the one hand, and of those of the canal society on the other, the charges necessary over the road to defray the cost of working and maintaining it would be six or seven times greater than for the canal, a fact conclusive as to their relative merits, conclusive as to all practical questions connected with them, and equally conclusive as to which of the two enterprises belongs to *true progress*. It requires no "life-time devoted to mechanical science" to see and appreciate these sound and common-sense points. No science is needed in their demonstration, and but a small quota will be needed in the construction of a safe, capacious, enduring, and economical ship-canal in Nicaragua.

I append the opinion of a well-known engineer who was appointed by the Government to make a personal examination of the Nicaragua Canal route.

Very respectfully, your obedient servant,

S. L. PHELPS.

Hon. C. G. WILLIAMS,
Chairman of the Committee on Foreign Affairs, House of Representatives.

ADDENDA TO FOREGOING LETTER.

To the Committee on Foreign Affairs, House of Representatives:

GENTLEMEN: In the month of February, 1874, General Humphreys, then Chief of Engineers, United States Army, requested that I should pass over the routes that had been surveyed in relation to a ship-canal across the Isthmus, and were then under consideration by a commission of which he was the president. He and myself were classmates, and graduated at the United States Military Academy in 1831, and from our long association, and his knowledge of my pursuits since I left the academy, he was good enough to say that he knew of no one whose opinion he would value more than mine in respect to the execution of an interoceanic canal.

Having consented to make the inspection, at the request of General Humphreys, I was invited, as a civil engineer, by the Secretary of the Navy, to inspect the routes designated. The position was honorary; no compensation was proposed, the reason assigned being that no appropriations existed for the purpose, and an adequate compensation to

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competent engineers was not within the means of the Department, but vessels of war would convey the party, which I was invited to join, and our actual expenses, subsistence, etc., would be provided by the Navy Department.

Under these conditions, I passed over the Nicaragua route, under the guidance of Commander Lull and Civil Engineer Menocal, U. S. N., who had made the surveys. I passed over the Lajas route, lying between the lake and the Pacific; also the Rio del Medio route. No surveys had been made at that time that assured the ready diversion of the headwaters of the Rio Grande into the lake, which have since been made. This establishes excellent surface drainage, and reduces the cost of the canal very considerably by the substitution of the Lajas route, now much preferable to the other.

Regarding the whole route from ocean to ocean, on a careful examination, aided by the surveys in passing along, I was struck with the ease and facility of execution, there being not one engineering difficulty, unless it be at the harbor of Greytown, which in itself, as compared with many harbors that have been made, imposes little relative difficulty of construction and maintenance. When at that point, without any previous discussion of the subject with the engineer, I defined the locality that I would select for operations, which fully coincided with his own.

I have no hesitation in expressing the opinion that after the work is fairly begun, four years, such as the seasons furnish in Nicaragua, should open the canal for transit from ocean to ocean; also that there is nothing in the work that should make the cost of the work extraordinary, or that is not fairly calculable in advance, and that is not presented in the estimates by Civil Engineer Menocal. I hope, therefore, Congress will do all in its power to promote the execution of the work. It is eminently practical, of great importance to our local traffic between our Atlantic and Pacific coasts, and not less important to us in establishing ourselves predominantly on the west coast of South America, and on the Isthmus itself, the population and productions of which will increase enormously.

Should the committee desire any special explanation in relation to the route, or as to matters of construction of the canal from me, I will appear at any specified time, but feel assured that it can rely fully upon the explanations and statements of Captain Lull and Mr. Menocal, both of whom are competent and reliable in every sense of the word.

JACOB AMMEN.

BELTSVILLE, MD., *April* 15, 1882.

APPENDIX TO MR. PHELPS'S ARGUMENT.

(1.)

OPINIONS OF SHIPBUILDERS.

"I am in receipt of your communication, and in reply I have to say that in my opinion a ship or steamer of large dimensions cannot in safety be taken out of the water with cargo on board, as there would be great danger of injury to the hull, and consequently cannot be safely transported with cargo on a ship railway.

"Very respectfully,

"JOHN ROACH."

William H. Webb, esq., the celebrated shipbuilder, concurs in this opinion.

The Harlan & Hollinsworth Company, of Wilmington, Del., say:

"If the foundations of the railroad, having six tracks, could be made *substantial, so as not to yield* under the immense weight of a loaded ship, we believe that a cradle could be constructed to receive the ship and transport it the distance named without injury. But to do so the ship would have to be constructed specially for such service, having such peculiarity of construction as would permit such handling without fear of injury. The ordinary wooden vessel of to-day would hardly venture upon such a journey overland; neither would underwriters take the risk of damage unless vessels were prepared for such service.

* * * * * * *

"We have read very carefully the letters written by Admiral Ammen to Mr. King. We think he has left very little to be said hereafter, as he has covered the ground fully."

The Pusey Jones Company, of Wilmington, Del., say:

"So far as relates to injury resulting to the vessel itself from being raised from the water while loaded, opinions will differ. A new strongly-built *iron* ship might endure this without damage, but in our opinion the element of danger of sustaining serious damage while being transported under such condition would be regarded by the average ship's owner as a risk which he would not be warranted in taking; and we are further of opinion that underwriters would share the ship-owner's views.

"In so far as the element of danger of sustaining damage relates to wooden ships, or iron ones whose plates have become thinned by age, the carriage proposed would be simply destruction.

"However well a ship might stand the strain of being quietly docked with a heavy cargo on board, the fact could hardly be used as an argument that she could be safely transported while so raised from the water; the dynamic effect of the load and of the boilers and machinery would be an element of danger that only extraordinarily strongly-built ships could resist, and very probably even these would not.

"As to the uniform solidity of the road-bed necessary to safety of transportation, we are of opinion that in a country so subject to heavy falls of rain as is that of the one on which it is proposed to make the road, the problem presented is so difficult as to be scarcely capable of solution.

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"Finally, we think the whole question of a ship-railway, as proposed, is so full of grave and scarcely surmountable difficulties that it is scarcely worth consideration."

T. F. Rowland, esq., Continental Works, New York, says:

"I have some crude notions as to the best method of moving large and heavy bodies, and feel certain that 'carriage on wheels' cannot be so classified, although it may be theoretically possible to equally distribute the weight of a moving body upon any desired number of supports, practically it is almost a mechanical impossibility to do so. A four-wheeled vehicle will equally load each, but if another pair of wheels be added they will carry the whole load or no part of it, as the road varies more or less from a perfect plane. In cars and locomotives eight wheels in place of four are desirable, but experience has proved they must be grouped in trucks, or harnessed with springs, equalizing bars, or other devices, in order that in effect the load must rest upon *four* points only. The car and locomotive are strong enough for this treatment, but not so the ship, whose shape, strength, and general make-up demand conditions of support which can best be obtained by being water-borne, and cannot otherwise without more or less injury to the structure. So it happens, when it becomes necessary to dry-dock or haul a ship, great judgment, care, and labor are demanded to know when and how to tighten or loosen the supports, and to perform the operation without seriously injuring the vessel. So much so is this the case I think it may be safely assumed that few vessels are dry-docked without sustaining more or less permanent injury."

The Atlantic Works of Boston say:

"Our positive ignorance of this matter throughout forbids our expressing any opinion at length. It does not seem to us a feasible plan, and we do not believe it will ever be accomplished. Were it not that Captain Eads has already 'done wonderful things' we should not hesitate to declare this scheme *impossible* of execution."

Opinion of C. H. Mallory, esq., a former shipbuilder, ship-captain, and now a large ship-owner:

"Your favor of the 20th, asking for an expression of our opinion of the practicability of transporting loaded ships over a railroad 100 miles 'without being water-borne' is received. * * * We have given some thought to this matter, and have believed it impossible to transport a loaded ship over miles of railroad in a cradle without being water-borne without great damage to the ship.

"It is considered highly dangerous to take a loaded ship out of water on one of our sectional or balance docks, and it is the rule, and it is required by underwriters in most instances, that the cargo in whole or part shall be discharged. It appears to me that an iron ship, loaded with heavy cargo, transported on a railroad over 100 miles (however smooth) without being water-borne or some equivalent would be very apt to require an entire new fastening of rivets before launching again."

(2.)

EADS'S PLAN—PRACTICAL VIEWS ON THE PROPOSED ISTHMUS RAILWAY.

PHILADELPHIA, *January* 28, 1881.

TO THE EDITOR:

I notice that Captain Eads has made a proposition to build a ship-railway across the Isthmus to carry ships loaded with their cargoes, and I beg herewith to say, as a practical shipbuilder, that such a proposition is nothing more than a delusion upon our people. I have built over one hundred ships, some of them the largest sailing ships in the world, and it is with the greatest care that all shipbuilders are compelled to lay the keels and see that the foundations for the launching ways have the very best possible bearing that can be devised, so that the vessel can be launched with safety, without injury to the hull, when sliding a distance of only one and one-half times its own length.

I also notice that our Government has been asked and it is thought that it will indorse the measure by guaranteeing some $50,000,000. Before any enormous expenditures are made it would be well to pause and consider what we are to receive for our money after the work is done and what are the benefits arising from it. Is the scheme a practical or a theoretical one? Speaking for myself—and I claim to speak from a practical stand-point, backed by years of experience in handling ships—I am free to say that I believe the enterprise a delusion, and there is not a single naval constructor or engineer in the Government employ, who lays any claim to practicability, who would be willing to indorse such a scheme, or stake his official reputation upon the success of any scheme requiring the carrying of a vessel, with her cargo, 100 miles overland, when it is a well-settled rule among them all to prefer to sail a vessel thousands of miles rather than launch her 300 feet with only her own weight (no cargo) upon the ways. * * *

NATHANIEL MCKAY.

(3.)

THE ATLANTIC WORKS, BUILDERS OF IRON AND WOODEN STEAMSHIPS,
East Boston, February 10, 1881.

DEAR SIR: Replying to yours of the 31st ultimo, in our opinion the railroad project will never be carried out, for the simple reason that it is not practicable and cannot accomplish the results claimed.

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The opinions expressed by Mr. Nathaniel McKay, in his article in the American Ship, is just *our* opinion regarding the railway.

As to the canal, while we confess ignorance as to details, we have no doubt of the feasibility and the beneficial results of its construction.

Very truly yours,

ATLANTIC WORKS,
ALFRED E. COX, JR.

Rear-Admiral DANIEL AMMEN, U. S. N.

(4.)

OFFICE OF DELAMATER IRON WORKS,
New York, February 11, 1881.

DEAR SIR: Your letter of January 31 was duly received with inclosures. We feel the subject is one that requires more careful investigation than we have been able to give the subject. We have read the articles sent us, and of course much other matter relating to this subject. We have never believed that the railroad scheme could be brought to an actual issue. We believe no private capital could be had for such a purpose. As large owners of steam vessels, we should not allow a steamer loaded with cargo to be taken out. Of course we recognize that such a feat can be done, as it is only a question of expense; but the expense would in our minds be entirely prohibitory. We have lately had experience with auxiliary power to sail vessels, fitting out three whalers, all eminently successful. We are led to remark this from a remark in one of your articles relating to sail vessels in canal. We think this subject one to be elaborated on in connection with the canal scheme. We have looked upon the difficulty of building either canal or railroad as so serious as almost to preclude the carrying out of either scheme.

We decidedly favor the canal over the railroad scheme, and it seems to us that there can be but one opinion as to the benefits to the commerce of the world, and to that of our own country particularly.

Yours very respectfully,

C. H. DELAMATER & CO.

DANIEL AMMEN, Esq., *Rear-Admiral, U. S. Navy.*

The above expressions of opinion comprise those of all the firms in our country, except one, which construct large iron ships, and that exception, it is well known, is not due to any difference in views, Messrs. William Cramp & Sons having expressed themselves very freely against the idea of ship transportation by rail. Their experience in attempts to take loaded vessels out on marine ways would be highly instructive to Captain Eads.

(5.)

OPINIONS OF UNDERWRITERS.

J. Parker, esq., of New York, writes as follows:

In all my experience during the last fifteen years as an underwriter's surveyor, and in my present capacity as a manager of a book of classification, I have never known a vessel to be docked with her cargo in, except for the purpose of raising her slightly in order to reach a leak a little under water. No dock-master would consent to raise a vessel laden with the cargoes that are likely to be sent hence to San Francisco, or thence through a ship canal, through a railway over the Isthmus of Darien, or Captain Eads's proposed route; and I am very decidedly of the opinion that no vessel so laden could safely be taken across such a railway, and then sent upon an ocean voyage. Certainly she could not be unless a new style of naval construction were first adopted.

As to the general subject, I suppose that, in the face of the experience of the Suez Canal, and the vast saving of time and distance worked out by that, no one can doubt that a ship canal through the Isthmus, or Nicaragua, would be a vast benefit in every way to the commerce of this country, and to the nations generally. I do not believe it would revive our commerce, or rather our mercantile marine; that will never be revived until the burdens it has to bear, from which the marine of all other nations are exempt, are taken off, but it will of course give additional advantages to the few vessels that now fly our flag, and are confined to the coasting trade.

Yours very truly,

J. PARKER,
Secretary.

(6.)

OPINIONS OF ENGINEERS.

William J. McAlpine, esq , second to no civil engineer in this country, wrote that he regarded the Eads scheme quite as visionary as M. de Lesseps's canal at the ocean level, and that he would discuss the subject without delay. Since that time illness has confined him to his bed, and so far delayed his expressed intention. His opinion has

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special value, as he has full professional knowledge of the ground, having recently spent months examining and locating the best lines for railway between the oceans.

NEW YORK, *June* 3, 1881.

DEAR SIR: While returning from Mexico, and on the steamer, I wrote a paper in which I thoroughly examined the Eads scheme of a ship railway across the Isthmus of Tehuantepec.

I had then just finished an exploration of the route which Mr. Eads's engineers had selected for his ship-railway.

This paper was sent to a gentleman in Mexico with a view to have it laid before the Government.

I intend to rewrite this paper for use before the Congress of the United States, and would be glad of any information or facts touching this subject which you may have collected, and upon which I can comment in my paper.

In your recent letter you speak of having obtained the opinions of all of the leading shipbuilders in the United States (except one) condemning this scheme. I would be obliged to you for a copy of one or more of these opinions.

In my paper I have described from *personal* surveys the route which his engineer has selected, and have spoken of the enormous cost and difficulty of carrying his roadway across the deep swamps of one-half at least of the first 60 miles, from near Minititlan; of the rough country of the mountain section over which his line must pass, crossing numerous streams (tributaries to the Cortez River), and the repeated changes of grades and lines rendered necessary thereby; of the south descent of the Sierra Madre slope (500 feet in 4 miles), and of the equally costly and difficult cutting through of the Coast range; of the difficulty of vessels descending into the constant turbulent Pacific (?) sea; of the mechanical impossibility of at all times equally distributing the weight of the ships, cargo, and cradle on 1,200 wheels over six ordinary railroad tracks, so that sometimes a hundred or less number of wheels must carry the whole load, and hence that the substructure must be immensely stronger than any railroad ever built; of the cost of the United States dry-dock at Brooklyn as an example, its foundation to support only 3,000 tons on firmer ground, cost more than at the rate of $500,000 a mile; of the inequalities of the surface of the rails of the best-built railroads ni the world, causing constant concussions with the maximum weight of forty tons, and would be multiplied by weights of five thousand to ten thousand tons, sufficient to destroy almost any track that could be built (the concussive effect being as 125 or 250 to 1), hence a speed of not exceeding one mile an hour would be necessary, or one hundred and fifty hours for crossing the Isthmus; of the difficulty, impossibility, of supporting a ship out of her element by shores which would only sustain the places where they were inserted, while at sea the ship has identically the same support (displacement) at every instant of time, no matter how rough the sea may be; of the tropical hurricanes which prevail on the Isthmus, when the whole broad-side of the ship, from her keel to her bulwarks, is exposed to the gale; that is, twice as much surface, besides top-hamper, as when afloat, and that the center of gyration (turning) when afloat is, say 4 to 8 feet below the surface of the water, but on the ship-railway is 5 to 10 feet *below the keel*, so that these hurricanes have twice the leverage to capsize the vessel, and, with double the area exposed, the hurricane has four times the power to overturn her; of the necessity of stopping at each change of grade or line to move the ship and cradle by turn-table, &c., producing delays greatly more than locks would cause.

* * * * * * * *

I write from recollection, and only give you these points to show the line of my argument.

* * * * * * * *

In great haste, I am, very truly and resp'y yours,

WM. J. MCALPINE.

Admiral DANIEL AMMEN, *Washington.*

Lieutenant-Commander Gorringe says:

"However successful Captain Eads may be in moving a laden ship across such a distance over such varying grades, the ship would not float on reaching the point where the floating would be a matter of some importance. * * * The jarring in motion, no less than the development of strains not provided for in ship construction, must inevitably open every seam and cause every rivet to leak."

(7.)

EAST WARREHAM, MASS., *February* 10, 1881.

MY DEAR SIR: You ask my opinion on Captain Eads's project for a ship-railway across the Isthmus, as you think I ought to know something on the subject from having had charge of the construction of railways, both marine and others, and not a little experience in canal-building. The first difficulty that presents itself to my mind in the case is the utter impossibility of transporting a loaded sea-going vessel of any considerable size for any distance over land with safety without such an expenditure of time and money as would make the operation perfectly useless for practicable purposes, unless Captain Eads has discovered some method hitherto unknown and yet unpublished for overcoming well-known physical laws. It is well understood by all ship-builders, ship-owners, and ship-masters that a loaded vessel cannot be hauled out of water with perfect safety on our best-constructed marine railways, even where the speed is so slow as to be hardly discernible; not one vessel in ten of our merchant marine will bear the strain and jar to which they are subjected; *hence it is never done, except in cases of the greatest emergency, and it is always an expensive operation.* Many instances can be given where unloaded vessels have been seriously injured from being hauled out on a marine railway, and innumerable are the instances where the calking has been started and seams opened from the inequality of the strain on the different parts of the vessel. I once had a small vessel hauled out on a railway at New

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Bedford; on being launched the calking started from one of the seams, making it necessary to beach the vessel to keep her from filling with water; and a similar case happened to me in Chesapeake Bay. It is considered dangerous for a loaded vessel to take ground, even under the most favorable circumstances. A nearly new and well-built vessel belonging to this town was seriously injured last year from grounding while coal-laden at a Boston wharf, though the wharf had been prepared for the reception of such vessels, and all danger from grounding supposed to be provided against. It is inferred by some, from the fact that loaded small boats are carried with safety on railways over inclined planes, that therefore vessels of any size can be transported on a railway, there being merely a difference of cost in the case. In 1851 I had charge of the reconstruction of four of the inclined planes on the Morris Canal, in New Jersey, and know something of their construction and operation. The canal was used as far as was possible, and the inclined planes put in only when great differences of levels were to be overcome in a short distance. This is a vast difference between building a railway for carrying a flat-bottomed canal-boat of 100 tons burden and four feet draught of water and one for a sea-going ship of 2,000 or 3,000 tons burden, with a draught of from 18 feet to 24 feet of water. Certainly no comparison favorable to a ship-railway can be made between them; it might, possibly, suggest the use of inclined planes instead of locks where water was scarce, a great saving of distance made, and vessels to be built expressly for the purpose.

The grading and superstructure for a railway of sufficient strength to sustain the weight of a 3,000-*ton ship must cost more to begin with than a canal of equal capacity*, and the cost of keeping it in repair would be far greater than that of keeping the canal in repair. It must be perfect in its construction, beyond the possibility of getting out of order from any cause, even a change of temperature. The car or cradle in which the vessel is carried must be so devised as to give the vessel as perfect bearing as in the water; all jars must be provided against; the weight must be so distributed among the car-wheels that they cannot break, as an accident in course of transit from a broken wheel or derailment would be ruinous to the enterprise.

Now, when all this is satisfactorily done, the question of the power required to move this great weight with any considerable speed, and how it shall be applied, presents itself and we are at once confronted with the fact that ships often stick on the ways in launching and are moved down grade with difficulty, noticeably in the case of the Great Eastern, where every emergency was supposed to be provided for by the best engineering talent. Though there has been no positive limit yet put to the weight that can be moved, it must be done at a very slow rate when more than a comparatively few tons are in one body.

These considerations are conclusive to my mind against the economic practicability of Captain Eads's project, and why the nation should not assist him in its demonstration any more than it should any person who should propose to carry a ship across the Isthmus in a balloon.

Very truly yours,

A. SAVARY, *Civil Engineer.*

Hon. JOHN CONNESS.

(8.)

WASHINGTON, D. C., *March* 12, 1881.

Capt. S. L. PHELPS:

Having been interested in the working of the caisson at the outlet lock of the Chesapeake and Ohio Canal, above Georgetown, D. C., for some time, my attention being first called to it by the necessity for a favorable solution of the problem as to introducing canal-boats from the canal to the river, in 1876 a "constructing engineer" and myself went over the work, but arrived at the conclusion that the best means had not yet been attained, which subsequent events seemed to prove. The gearing, not being adapted to the heavy strain, gave way, causing the death of at least one, and I think more, of the employés.

My attention has been again drawn to the matter, since the proposed construction of a ship-railway on the Isthmus.

I have taken some pains to have the verdict of our steam-tug and canal boatmen, who are most interested, and below have given their testimony, generally in their own words, prefacing the statements, however, with the size and weight of the caisson, which is 112 by 15 feet, and weighs, when filled with water, 400 tons:

Capt. A. C. Wilkinson, of the steamer W. Moore, says that a perfectly new boat may stand the strain, but an old boat never leaves the tank without sustaining such damage as to cause her to leak badly; that he's afraid to go in the tank, now that they take the water out and let the boat down on the bottom of the tank, straining her and opening all her butts. He has seen the rails chewed up like so much paper by the truck wheels, and men replacing the worn rails almost every night, though the rails were much heavier than common; that the track settled badly, except in the part where it was solid stone masonry under the whole track; that is, from side to side. He thinks they have put stone under every portion of it during the past winter; is sure that is the only way to prevent the heavy weight from sinking right down (and yet this is only 400 tons distributed over 112 by 16 feet.)

The steamer Ludlow Patten always leaks terribly after going in the caisson. She sprung two of her deck beams last season, and would not go into the river that way, if there was water enough in Rock Creek.

Canal-boat Nathan Williams, Captain Zimmerman, always leaks after going into the tank with a load; does not suffer when going up light, as then the tank is filled with water. Canal-boat Blue Bell, Captain Russell, and several others, make the same report.

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Canal-boat Johnson, Capt. Milliard Engle, though comparatively a new boat (this being her first season), yet shows the strain; her deck-plank butts gaping wide open every time she enters the tank with a load.

Canal-boat F. W. Winthrop suffers terribly every time she goes into the tank with a load. The captain wishes the old tank was out of the way. He is afraid every time he enters it, except when he is empty.

Capt. James Christy, tug-boat Major, says he has towed many of the canal-boats from the caisson to Georgetown, and never heard one of the captains speak in its praise; on the contrary, all condemn it, and many say they are afraid of it when they go in loaded. He heard that last year a boat was so badly injured that she sunk immediately after leaving the caisson.

Capt. T. Milstead, tug-boat A. P. Gorman, says he has towed a large number of canal-boats from the incline to Georgetown and back; does not remember to have heard many captains praise it, but has heard almost all say they were afraid of it. He towed the canal-boat Kennah in December, 1880. She was injured so badly that he saw she was settling directly she came out of the caission, and he ran her ashore as soon as he could, when she sunk.

Yours truly,

J. H. HALL.

(9.)

UNITED STATES ENGINEER OFFICE,
26 *Washington Avenue, Detroit, Mich., July* 14, 1879.

MY DEAR DAVIS: I have received your letter of the 8th instant. I expect to be able to pass a single vessel through the new lock at Saint Mary's Falls Canal, when everything is in good working order, in 11 minutes, as follows, viz:

	Minutes.
Entering lock chamber	1½
Closing gates	1
Filling lock	6
Opening gates	1
Leaving lock chamber	1½
Total	11

The chamber is 515 feet long and 80 feet wide, except at the gates, where it is reduced to 60 feet in order to diminish the size and weight of the gates. There is a single lift of 18 feet.

The gates of the old locks are operated by very primitive methods and by hand. The chambers are 350 feet long and 70 feet wide. There are two lifts of 9 feet each. Thirty-seven vessels have been passed through the locks in twenty-two lockages in twenty-two hours.

The chambers of the new locks of the Louisville and Portland Canal are 372 feet long and 80 feet wide. There are two lifts of 14 and 12 feet. The gates are very heavy. One leaf of the middle gate weighs over 90 tons. The machinery for operating the gates is worked by hand. Yet we have made twenty-nine lockages in twenty-one and a quarter hours. I am now applying engines to each capstan, and will operate these engines by compressed air. I also have commenced rebuilding the gates in order to get them lighter. * * *

There is no other ship-canal at just such a place as this one, and no other ship-canal can be compared to it on account of the immense quantities of silt.

The new lock of the Saint Mary's Falls Canal is the largest canal lock in the world. There is a dead lock in Liverpool, between the north basin and the Canada Dock, which is 100 feet wide and 500 feet long.

To pass the *Ville de Paris* through a lock of 12 foot lift with modern improvements would require about eight minutes.

Very truly yours,

G. WEITZEL.

Major GEORGE W. DAVIS, *Washington, D. C.*

(10.)

UNITED STATES ENGINEER OFFICE,
26 *Washington Avenue, Detroit, Mich., July* 31, 1879.

MY DEAR DAVIS:

* * * As far as my time has permitted (I am not allowed to read at night), I have looked over Mr. Menocal's designs and estimates. His design appears feasible. His estimates are close, but he has added a large percentage for contingencies.

He ought to increase the capacity for filling and emptying the locks, so as not to take more than from six to eight minutes. Each lock should be provided with guard gates on each end, so that they can be pumped out for repair. * * *

Very truly yours,

G. WEITZEL.

Major G. W. DAVIS, U. S. A., *Washington, D. C.*

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(11.)

OFFICE OF W. R. HUTTON, *Civil Engineer*,
46 *Lexington Street, Baltimore, March* 24, 1881.

MY DEAR ADMIRAL: The angle of inclination of the incline for boats above Georgetown is 6° 50′, or a rise or fall of 1 in 12. The counterweights which balance it slope 1 in 10.

I have read Eads's paper in North American Review. I have not the time just now to investigate the strains in a loaded ship on his railway, as under other circumstances I would do; but his paper is open to criticism. He refers to the canal-boat incline, but no comparison can be made between that work and his project. In that the boat was carried in water, in order to maintain always the same weight in the caisson independently of the weight of the boat, so that a uniform counterweight would always balance it within the limits permitted by the friction of the wheels, &c. The friction has been so far beyond anything we could have expected, rendering unnecessary any nice balancing of weights, and the loaded boats which do not vary in weight more than ten or twelve tons (and very rarely so much), are now carried down resting on the bottom of the caisson, the light boats only being carried afloat in about 20 inches of water.

Your idea of the effect of the overhang is correct; only the pressure upon the end wheels depends upon the *stiffness* of the ship. If she were *perfectly* rigid, the weight would be evenly distributed over all the wheels, supposing *perfect* workmanship. The more flexible the ship the greater the pressure on end wheels. It would be more rational to increase the number of supports at the heaviest part and diminish where lighter.

I will be very glad to see Phelps's paper when published.

Very truly yours,

WM. R. HUTTON.

Admiral D. AMMEN, *Washington.*

(12.)

"ANCHOR" LINE
TRANSATLANTIC, PENINSULAR, MEDITERRANEAN, AND ORIENTAL STEAMSHIPS,
47 *Union Street, Glasgow, 26th February*, 1881.

DEAR SIR: We duly received your communication under date of 12th ultimo, respecting a ship-railway across the Isthmus of Tehuantepec. Such a scheme as you refer to is not new to us. As so long back as 1849 it was freely discussed both in Panama and San Francisco. The principal objections made to the scheme were:

1st. The difficulty of gradients.

2d. The difficulty of maintaining a solid foundation.

3d. The enormous weight to be transported.

4th. The difficulty of supporting the ship with a full cargo on board.

5th. The enormous cost of making and maintaining such a railroad.

The principal practical difficulty, in our opinion, is that of supporting the ship so that she may not be *strained* during the journey with her cargo on board—that is to say, with ships built as at present—and we think it could only be done by placing the ship in a trough or pontoon filled to her load line with water, so that she might be almost, if not entirely, afloat all the time. The spaces at the rim and entrance could be partly filled with air bags, to lessen the quantity of water, whereby the whole weight to be carried would be lessened to that extent.

Taking everything into consideration, we are of opinion that a ship-canal would be more likely to succeed as a commercial enterprise. No such railroad as the one proposed has ever been constructed, and many engineering and mechanical difficulties would doubtless crop up in the progress of such an undertaking, and possibly it might ultimately be found altogether impracticable. We would not, therefore, recommend the promotion of such a scheme.

If we can afford you any other necessary information, we shall be glad to hear from you when you so require. We are

Yours, very respectfully,

HENDERSON BROTHERS.

Rear-Admiral D. AMMEN, U. S. N., *Washington, U. S. A.*

(13.)

I have seen a statement made in connection with construction of the Tehuantepec Ship-Railway that no earthquakes occur in that country. I was a member of the Shufeldt Surveying Expedition to the Isthmus of Tehuantepec, in 1870 and '71, and my memory distinctly recalls the impressions of four earthquades that occurred there during our stay, from November to May. The first was felt at La Chivela, at the entrance to the Chivela Pass, over which Eads proposes to take his railway. In the early part of February, 1871, I was at La Venta de Chicapa, the guest of Señor Don Magneo. While sitting at the supper table we were aroused by a noise which threw the whole village into con-

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fusion. Following my host, we were soon out of the house and reached the gate in time to grasp its post, and was thus prevented from falling. After an interval of about a minute another shock occurred, and the ground heaved decidedly. We went back into the house after it was all over, and the Don examined the walls and found them intact, but he directed my attention to a large crack which traversed the entire length of one of the walls of his massive adobe house. He told me that that was produced by a very severe earthquake which had occurred some time previously. I have lived in Japan the greater part of three years, and while there was a witness to nearly one hundred earthquake shocks, but I have no recollection of having felt one harder than that here mentioned. La Venta de Chicapa is situated at the foot of the Tarifa Pass, the second of the two passes mentioned in connection with the roadway. The two other earthquakes took place while we were in the mountains, in the vicinity of Santa Maria Chimalapa. One occurred at night, and so twisted the house that we were in that we found the windows and doors jammed the next morning.

THOS. H. STREETS,
P. A. Surgeon, U. S. N.

(14.)

PRESSURES UPON THE DRIVING-WHEELS OF LOCOMOTIVES.

[Taken from Appleton's Encyclopedia of Applied Sciences, edition 1880.]

	Pounds.
Two engines, models by Grant, each	10,500
	10,500
One engine,	10,500
One engine, models by Baldwin, Mogul included	9,000
One engine,	11,000
One engine,	10,250
One engine, models by Hinckley	12,000
One engine, by Danforth	10,804
One engine, by Frank	11,000
One engine, by Rogers	10,000
One engine, by Mason	11,000
Average	10,550
Or in tons	4.7

(15.)

DIMENSIONS AND WEIGHT OF SOME STEAMSHIPS.

Name.	Length of keel.	Over all.	Beam.	Draft.	Gross tonnage.	Displacement.	Cargo carrying capacity.	Owners.
	ft. in.	ft.	ft. in.	ft. in.		Tons.	Tons.	
Tokio and City of Peking	423	.....	48	24 6	.....	9,000	4,050	Pacific Mail Steamship Company.
Germanic	455	.....	45	26	5,000	10,000*	4,300	White Star Company.
Britannic								
Gallia	430	.....	44	25	4,809	8,800	.....	Cunard Company.
Arizona	450	.....	45 4	26	5,100	10,000	.....	Guion Company.
Egypt	440	.....	44	25 6	4,670	9,160	.....	National Company.
City of Berlin	489	513	45	26	5,491	11,050	.....	Inman Company.
Servia	525	.....	52	26	8,500	13,182	6,500‡	Cunard Company.
City of Rome	546	600	52 3	26	.....	13,500†	.....	Inman Company.
Longhirst	285	.....	36 2	22 6	2,093	4,310	.....	English.
Colon	280	.....	40	20	.....	3,740	.....	Pacific Mail Steamship Company.
Bucentaur	282 3	....	33 3	22	1,765	3,834	.....	English.
Felicia	236	.....	31	16 5	.....	2,242	.....	Do.

* Obtained from the builders' scale at the White Star office, New York.
† Stated by builders, Barrows Shipbuilding Company.
‡ Stated by builders, Messrs. J. & G. Thomson.

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(16.)

TABLE SHOWING THE EFFECTIVE HAULING CAPACITY OF ENGINES OF 27 TONS WEIGHT.

[See Appleton's Encyclopedia of Applied Science, edition 1880.]

	Tons.
For level grade	729 to 892
For 10 feet per mile ascending grade	469 to 626
For 20 feet per mile ascending grade	343 to 454
For 30 feet per mile ascending grade	268 to 358
For 40 feet per mile ascending grade	218 to 292
For 50 feet per mile ascending grade	183 to 244
For 70 feet per mile ascending grade	137 to 184
For 100 feet per mile ascending grade	97 to 130
For 120 feet per mile ascending grade	79 to 106

(17.)

All voyages between ports in either ocean north of the latitude of Tehuantepec, so far as regards *actual distance only*, would be favored more or less by that route; and all voyages between all ports in the Atlantic and those to the south of Tehuantepec, in the Pacific, would be favored in *all respects via* Nicaragua.

[Page 6, Mr. Nimmo's report.]

TABLE 1.—*Number of vessels and amount of tonnage which might have passed through the proposed canal if it had been constructed.*

[N. B.—This table is based upon statistics of the latest year for which the requisite data can be obtained.]

	No. of vessels.	Tons.
1. Average number of vessels and amount of tonnage entered at and cleared from either side of the Isthmus of Panama, annually, in trade with all nations* (Appendix 2 and 3)	338	533,000
2. Vessels entered and cleared from Pacific ports of the United States in trade around Cape Horn with Atlantic ports of the United States during the year ended June 30, 1879† (Appendix 4)	75	120,662
3. Vessels entered at and cleared from Atlantic ports of the United States in trade with foreign countries west of Cape Horn, during the year ended June 30, 1879 (Appendix 5)	273	247,567
4. Vessels entered at and cleared from Pacific ports of the United States in trade with foreign countries east of Cape Horn, during the year ended June 30, 1879 (Appendix 6)	455	551,929
5. Vessels entered at and cleared from ports of the several countries of Europe in trade around Cape Horn with foreign countries other than the United States, during the latest year for which the data can be stated with respect to each country (Appendix 7)	1,644	1,462,897
6. Vessels entered at and cleared from ports of British Columbia in trade with countries of Europe, during the year ended June 30, 1879	33	22,331
Total	2,818	2,938,386

* An estimate from the report of the United States consul at Panama (Appendix 2), and from a statement compiled from British consular returns (Appendix 3).

† Compiled from special reports by collectors of customs.

[Page 8.]

TABLE 2.—SHOWING THE TONNAGE ENGAGED IN GUANO AND NITER CARRYING, VIA CAPE HORN, A BUSINESS CONDUCTED BY SAILING VESSELS.

	Vessels.	Tons.
Westward passages, via Cape Horn	314	314,000
Eastward passages, via Cape Horn	496	496,000
Total	810	810,000

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[Page 9.]

TABLE 3.—SHOWING THE DEDUCTIONS MR. NIMMO ESTIMATES SHOULD BE MADE FROM THE GROSS AMOUNT OF TRADE WHICH MIGHT HAVE PASSED THROUGH A CANAL, AS SHOWN PER TABLE, PAGE 6, AMOUNTING TO 2,938,386 TONS.

	Vessels.	Tons.
(*a*) Vessels employed in trade between Atlantic ports of the United States and Australia	79	53,685
(*b*) Vessels employed in trade between Atlantic ports of the United States and Chili	24	17,120
(*c*) Vessels employed in trade between Europe and Chili	372	368,193
(*d*) One-half of the tonnage employed between Atlantic ports of the United States and China and Japan (estimated)	52	64,604
(*e*) Vessels engaged in guano and nitrate of soda trade between Atlantic ports of the United States and ports of Europe, with the western coast of South America	810	810,000
Total	1,337	1,313,602

Deducting the above amount from 2,938,386 tons, he arrives at 1,624,784 tons as representing the probable business of the canal.

The several amounts of tonnage in Table 1, with the exception of 2 and 6, contain items of carriage between ports lying to the north or to the south of Tehuantepec, to be credited to each of the routes, as follows:

Item 1. Traffic over Panama Railroad with San Francisco (page 19) 30,734 tons, credit to Tehuantepec.

Item 3. China and Japan trade, 129,208 tons, credit to Tehuantepec.

Item 4. Trade with Brazil and Africa (Appendix 6), 18,568 tons, credit to Nicaragua.

Item 5. Trade with west coast of Mexico (Appendix 7), 11,438 tons, credit to Tehuantepec.

Distributing the amounts according to the indications given in the table, and correcting as above, the following results are obtained:

	Tonnage for which Tehuantepec would be the shorter distance.	Tonnage for which Nicaragua would be the shorter distance.
	Tons.	*Tons.*
Item 1	30,734	502,266
2	120,662	.....
3	129,208	118,359
4	533,361	18,568
5	11,438	1,451,459
6	22,331	.....
Totals	847,734	2,090,652

That is, of the total carrying trade between the Atlantic and Pacific ports, as per Mr. Nimmo's table, five-sevenths would be favored by the Nicaragua route.

Mr. Nimmo made deductions as per Table 3, by which he reduced the probable business of a canal to 1,625,000 tons

In these deductions one-half the carrying trade between our Atlantic ports and those of China and Japan is included, and in order to ascertain what proportion of 1,625,000 tons carrying business Tehuantepec would favor in distance, that trade must be deducted from the amount above credited to the route:

	Tons.
Proportion for which Tehuantepec was before found to be the shorter distance	847,734
Deduct half trade with China and Japan (item 1, page 9)	64,604
Carrying trade for which Tehuantepec is the shorter route	783,130
Total Mr. Nimmo's estimated traffic	1,625,000
Carrying trade for which Nicaragua would be the shorter route	841,870

In further discussion of this subject it will be shown that Nicaragua is quite as favorably situated as Tehuantepec for all this carrying business, except that between our own ports on the two oceans and also that between our Atlantic ports and those of the west coast of Mexico.

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Assuming this to be the case, the following results are shown by Mr. Nimmo's tables:

	Tonnage via Tehuantepec as the shorter route.	Tonnage via Nicaragua as the shorter route.	Tonnage which might take either route.
	Tons.	*Tons.*	*Tons.*
Item 1	30,734	502,266	.....
2	120,662	.....	.....
3	.....	118,359	129,208
4	.....	18,568	533,361
5	11,438	1,451,459	.....
6	.....	.....	*22,331
	162,834	2,090,652	684,900

OR, ON THE BASIS OF 1,625,000 TONS CARRYING TRADE—

Item 1	30,734	502,266	.....
2	120,662	.....	.....
3	.....	118,359	129,208
4	.....	18,568	533,361
5	11,438	138,093	.....
6	.....	.....	*22,331
	162,834	777,266	684,900

*Supposed to be with European ports.

Thus it appears that of the carrying business Mr. Nimmo found for a canal, 162,824 tons would be favored by Tehuantepec; 777,266 tons by Nicaragua; and 684,900 tons, other things than distance being equal, would take either route with like advantage.

The grain carrying from the Pacific Slope would make much larger figures for Item 4, Table 1, than Mr. Nimmo gives; but this business being conducted with European ports would not add a ton to the list *favored by Tehuantepec*, but would pass to the third column above.

(18.)

DISTANCES NEW YORK TO SAN FRANCISCO.

	Distance adopted.	Distances, from report of Commodore Shufeldt.	Distances, from report of General Barnard.
	Miles.	*Miles.*	*Miles.*
Via Panama	5,245	5,300	5,039
Via Nicaragua	4,871	.....	4,704
Via Tehuantepec	4,311	4,400	3,983
For sailing vessels	4,320	.....	.....

DISTANCES NEW ORLEANS TO SAN FRANCISCO.

Via Panama	4,676	4,650	4,552
Via Nicaragua	4,151	.....	3,940
Via Tehuantepec	3,103	3,070	2,904

Distance New York to San Francisco, via Panama	5,245
Distance New York to San Francisco, via Tehuantepec	4,311
Difference in favor of Tehuantepec	934
Difference as stated by Captain Eads	1,500
Error in Captain Eads's statement	566

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WASHINGTON, *March* 15, 1882.

DEAR SIR: Please find herewith letter from Capt. C. G. Lundborg, engineer and naval constructor, regarding the feasibility of a railway for the transportation of loaded ships. Captain Lundborg, formerly an officer in the Royal Swedish Navy, stands very high among the naval constructors of Europe. Having also commanded ships afloat, he is especially competent to express an opinion upon the points involved, while his high integrity gives his professional opinion an especial value.

With much respect, truly yours,

WILLIAM L. MERRY.

Capt. S. L. PHELPS, *Washington.*

WASHINGTON, D. C., *March* 15, 1882.

DEAR SIR: I have had the honor of receiving your note of 13th instant, asking my opinion with regard to "the feasibility of transporting loaded ships of such tonnage as now in use over a ship-railway."

Before attempting a reply to your question, I would first observe that there is no such railway in existence for transporting large vessels for any considerable distance over land, the marine railways in use being for the purpose of hauling vessels out of the water on docks for survey or repairs, and there is accordingly no previous experience to assist in solving the problem.

The subject is of such magnitude, embracing so many points of vital importance, that it can hardly be properly discussed within the limited space of a letter; but the conclusions resulting from some thought given to it are anything but favorable to such a project.

As the displacement of some modern steamships now afloat exceeds 13,000 tons, and as in all probability yet larger vessels will be built within the near future, such a railway, if intended to meet the requirements of commerce at large, should, I take it, be capable of transporting a ship weighing with the cradle supporting it at least 25,000 tons.

Granting that all the formidable engineering difficulties of constructing such a road, with all the solidity and perfection necessary, could be overcome, the bare possibility of which may be conceded, as being purely a question of money and time, the remaining part of a successful solution of the problem would consist in the removing of the ship with cargo from the element in which she floats on the railway, the transportation for some distance over land, and her removal from the road into the water again.

The first and last of these operations would be about the same as practiced on the marine railways for repairing vessels, but it must be remarked that this is very seldom done with ships having the cargo in, and would rarely, if ever, be permitted by the underwriters without extra heavy premiums, on account of the imminent risk of damage, seeing that no possible shoring up, with ever so many *points d'appuis* in the cradle, could effectually replace the support of the water, distributed as it was over every point of the hull's surface. Now the risk of damage must increase with the distance that the ship would have to be carried, and it would become still much greater with the higher speed that might be attempted on the level part of the road.

If it was possible to build the road with mathematical exactness, on unyielding ground, of unyielding materials, and with the great number of wheels and axles, upon which the great load should rest, all of exact size and form, the work of moving a large loaded ship over such a road might be accomplished without much risk of damage to her hull; but inasmuch as no such perfection of workmanship or materials is attainable, there would inevitably, even at a very low speed (three or four miles per hour), occur such jars and vibration, together with occasionally heavy strain suddenly thrown upon certain points, that could, in my opinion, hardly fail to loosen rivets and joints, if an iron ship, or open seams and loosen fastenings, if a wooden one, or do other serious damage.

No doubt ships could be built with additional expense strong enough to stand the ordeal of such a trip, but even then there would yet—even with the best possible preparations without regard to cost or capital expended—always remain obstacles to a successful traffic over such a road, formidable enough to make a ship-railway for the purpose of carrying loaded vessels of large tonnage some distance over land a most unpromising undertaking. As ships now are built, either for merchant service or for war purposes, I cannot but consider any such scheme as impracticable, or as one that ought not to be seriously entertained with the slightest hope of success.

I am, dear sir, with great respect, your obedient servant,

C. G. LUNDBORG,
Engineer and Naval Constructor.

Capt. WILLIAM L. MERRY, *Washington.*

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A LIST OF WORKS HAVING REFERENCE TO THE SUBJECT OF INTEROCEANIC COMMUNICATION.

TEHUANTEPEC.

The Isthmus of Tehuantepec, being the results of a survey for a railroad to connect the Atlantic and Pacific Oceans, made by the Scientific Commission under the direction of Maj. J. G. Barnard, by W. W. Williams. New York. 1852.

Survey of the Isthmus of Tehuantepec, 1842–'43, under a scientific commission appointed by the projector, Don José de Garay, 1842. Journal of the Royal Geographical Society, vol. XIV.

The Isthmus of Tehuantepec. Herr M. G. Hermesdorff. Journal Royal Geographical Society, vol. XXXII.

Account of the Isthmus of Tehuantepec, with proposals for establishing a communication between the Atlantic and Pacific Oceans, based upon the surveys and reports of a Scientific Commission appointed by the projector, Don José de Garay.

Notes of an Excursion to the Isthmus of Tehuantepec. R. Dale. London. 1851.

Report of Capt. R. W. Shufeldt, U. S. N., commanding Tehuantepec Surveying Expedition. 1871.

Charter of the Tehuantepec Transit Company, granted October 15, 1866.

Observations in relation to a communication between the Atlantic and Pacific Oceans, through the Isthmus of Tehuantepec, founded on a report of this subject by Señor Gaetano Moro, under whose direction a scientific survey of the Isthmus was made. New York. 1849.

A Review of the Tehuantepec Controversy, containing notes on the "Memorial" of Senor Ramirez, the speeches of Messrs. Seward and Hale, of the United States Senate, and the letter of Colonel Benton. By the counsel of the claimants under the charter of Don José de Garay. Georgetown. 1853.

The Tehuantepec Railway, its location, features, and advantages under the La Sere grant of 1869. New York. 1869.

Review of the proposed Tehuantepec Ship Railway. June 1, 1881. By S. L. Phelps.

HONDURAS AND COSTA RICA.

Report to the Directors of the Honduras Interoceanic Railway Company. E. G. Squier. London. 1858.

Chemin de fer Intérocéanique de Honduras. Rapport de E. G. Squier. Paris. 1855.

Explorations and adventures in Honduras. W. O. Wells. 1857.

Les Grandes Voies du progrès Suez et Honduras, avec cartes, par Henri de Suckau. Paris. 1869.

Une Voie Nouvelle à travers L'Amérique Centrale. Étude Géographique, Ethnographique et Statistique sur le Honduras, par Henri de Suckau. Paris. 1866.

Historical account of the mischances in regard to the construction of a railway across the Republic of Honduras, by D. Ramon de Silva Ferro. Contained in Appendix No. 12, report of Select Committee on Loans to Foreign States. Parliamentary Papers. 1875. No. 367.

Interoceanic Railroad through the Republic of Costa Rica, by F. Kurtze, C. E., Director-General of Public Works. New York. Gray & Green. 1866.

Notice sur le Golfe Dulce dans l'État de Costa Rica, et sur un nouveau Passage entre les deux Océans, avec une carte, par M. Gabriel Lafond de Lurcy, Consul-Général, Chargé d'Affaires de Costa Rica en France. Paris. 1856.

NICARAGUA.

Report on Interoceanic Ship Canal from San Juan del Norte to Brito, Nicaragua. O. W. Childs and J. D. Fay. 1852.

Nicaragua: The proposed Interoceanic Canal. E. G. Squier. New York. 1858.

Memoria Histórica sobre el Canal de Nicaragua. 1855.

Pamphlet on Nicaragua, with initials L. N. B. Published in London, 1847, and printed in Revue Britannique for 1859, and M. Belly's "Percements de l'Isthme." London. 1859.

Nicaragua: Past, Present, and Future. By P. A. Stout. Philadelphia. 1859.

Report of Commander E. P. Lull, commanding Nicaragua Surveying Expedition. 1873.

Interoceanic Canal Question. Rear-Admiral Daniel Ammen, U. S. N.

Canal Interocéanico maritimo de Nicaragua. Projecto nuevo. Par A. P. Blanchet. 1879.

Canal Interocéanique maritime de Nicaragua: Notes et Documents présentés au Congrès de Géographie de Paris, du 15 Mai, 1879. À l'appui du projet de M. A. P. Blanchet, par MM. J. Pruchet et G. Sautereau, Ingénieurs Civils.

Memoria de Hacienda del Bienio de 1871 i 1872, presentada al Congreso ordinario de 1873, por T. M. Cardenas. Managua, State of Nicaragua.

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Mensaji Dirijedo al Soberano Congreso, por el Señor Presidente de la República, Don Vincente Quadra. Managua. 1873.

The Interoceanic Canal via Nicaragua. Address delivered June 24, 1870, by John E. Body, Esq.

Descriptive account of Captain Bedford Pim's Project for an International Atlantic and Pacific Junction Railway across Nicaragua. Report and estimate of cost. By John Collinson, C. E. London. 1866.

Examen comparatif des divers projets de Canaux Inter-Océanique par l'Isthme de Darien et le Lac de Nicaragua, par MM. J. Pouchet et G. Sautereau, ingénieurs civils. Bourges. 1876.

Report on an inspection of the terminal points of the proposed canals through Nicaragua and the Isthmus of Darien. By Professor H. Mitchell, United States Coast Survey. United States Coast Survey Report. 1874.

International Canal Projects. A paper by A. G. Menocal, member of American Society of Civil Engineers. Read before the society November, 1879.

Explorations in Central America, accompanied by survey and levels from Lake Nicaragua to the Atlantic Ocean. By John Collinson, C. E., F. R. G. S. vol. XII, R. G. Society Journal.

Le Nicaragua, Légendes et Notes. Lettre à M. Michael Chevalier, Sénateur, par Paul Lévy. Bullétin de la Société de Géographie. Mars, 1870.

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NICARAGUA SHIP CANAL.

BRITO HARBOR

Showing the proposed Breakwater and

Entrance to Canal

1873.

PACIFIC OCEAN

Scale 1/10 000

Prevailing Winds from North & Eastward, ten months in the year.

James B Philp, Draughtsman.

H. EX. 107, 2, 47.

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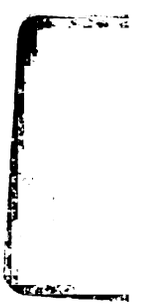

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